AATT TO 24

Communications System Architecture Development

for

Air Traffic Management and Aviation Weather Information Dissemination

May, 2000

AATT TO24
SAIC Team

Agenda

- ✈Task Overview
- ✈Requirements Collection
- ✈Candidate Architecture Concepts
- ✈Functional Architecture
- ✈Current/Near Term Link Definition
- ✈Communication Load Analysis
- ✈Architecture Alternatives
- ✈Transition Schedules
- ✈Gap Discussion
- ✈Summary

AATT TO 24 Team

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Task 1 Identification of User Needs	**Task 2** Communications System Functional Requirements	**Task 3** Communications System Engineering Requirements	**Task 4** Preliminary Comm. System Architecture Concepts
Task 5 2015 AATT Architecture	**Task 6** 2007 ATM Architecture	**Task 7** 2007 AWIN Architecture	**Task 8** Transition
Task 9 Current Data Links	**Task 10** Communications Technology Gaps	**Task 11** Areas for Research and Development	**Final Report** May 26, 2000

Task Relationship

Task 1: Identification of User Needs

Task 2: Develop Communications System Functional Requirements

Task 3: Develop Communications System Engineering Requirements

Task 1,2,3 Database

Task 4: Develop Preliminary Candidate Communications System Architecture Concepts

Task 9:Characterize Current and Near-term Communications System Architecture

Communications System Architecture

Requirements Analysis

Task 5: Develop 2015 AATT Architecture

Task 6: Develop AATT 2007 Architecture

Task 7: Develop AWIN 2007 Architecture

Task 8: Transition Plan

Task 10: Identify Comm. System / Technology Gaps

Task 11: Identify Components for R&D

Requirements Collection

Task 1

Identification of User Needs

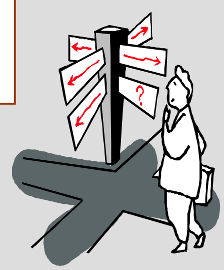
Task 2

Communications System Functional Requirements

Task 3

Communications System Engineering Requirements

Master Source List



Task 1

FARs
Concept Documents
Industry Reports

Task 2

RTCA DO's
FAA Requirements Documents
Consultant Studies and Reports
Concept Documents

Task 3

ATN SARPs
RTCA DO's
FAA Requirements Documents
Consultant Studies and Reports
EuroControl Documents

Approach

Relationship Between Tasks

Task 1 1-3

User Needs

"The User"

- Service or capability required to support the air space user
- Independent of communications medium
- Document-specific references
- Categorized by phase Of flight, user type, communication flow, ***functional capability***

Task 2

Functional Comm Requirements

"The Message"

- Data, message and/or operation that must be supported by communications architecture
- Independent of communications medium
- Document-specific references
- Categorized by ***functional***, ***capability***, and ***user services***

Task 3

Engineering Requirements

"The Pipe"

- Requirements that drive the overall system architecture
- Based on documented performance characteristics
- Categorized by application
- Influences selection of communications medium
- Document-specific references
- Associated with ***user services***

Remaining Tasks

Architecture Validation

Data Repository

Engineering Requirements

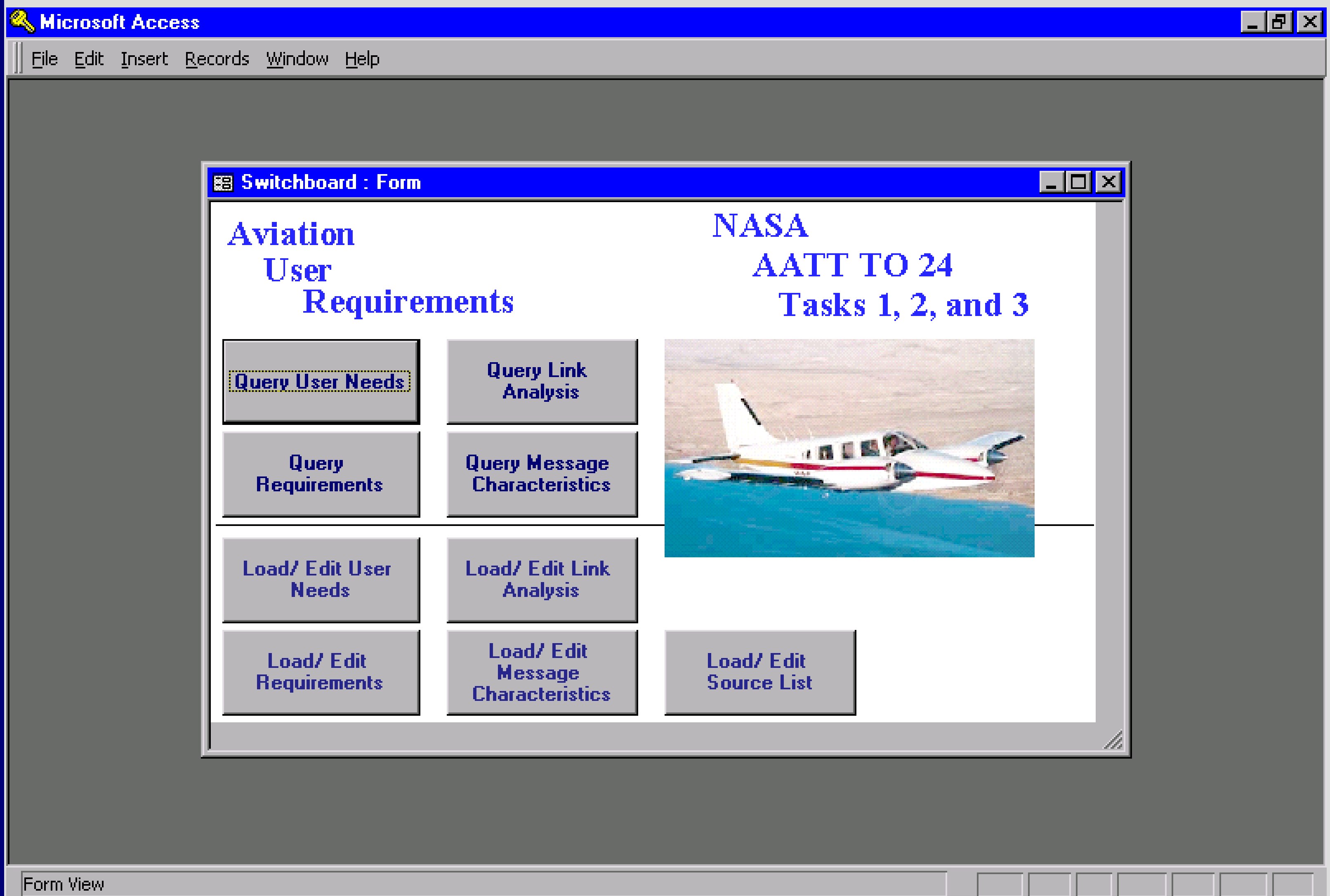
User Needs

Requirements Database

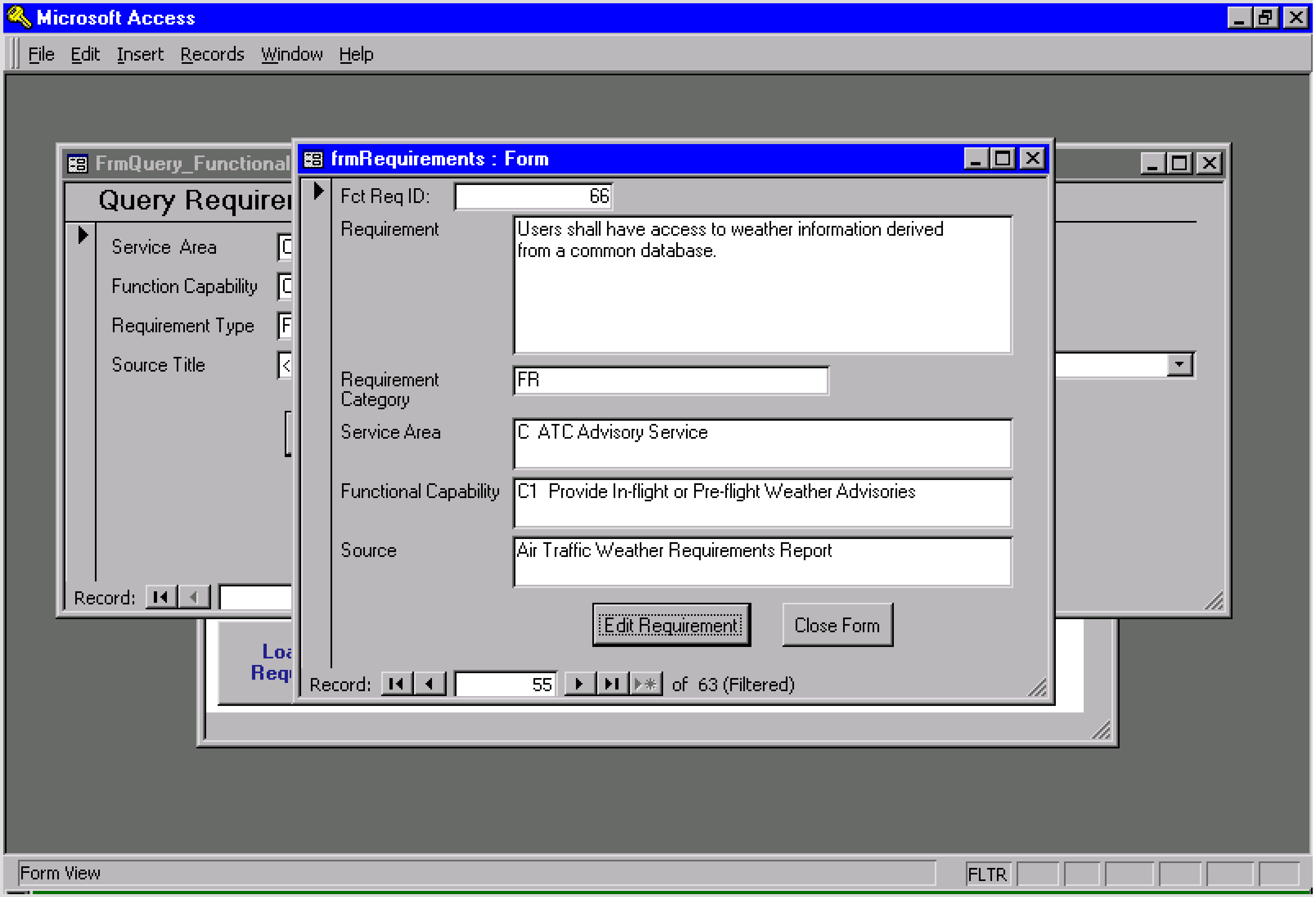
Functional Communications Requirements

Airspace Users	Message Characteristics
Functional Capabilities	Communications Requirements NAS
Service Architecture	Delay, Availability, Integrity
System Level Requirements	Source Traceability

Database Screen



User Friendly Forms



Task 4
Preliminary Candidate Comm. System Architecture Concepts

Task 4 developed a common base for architecture concepts.

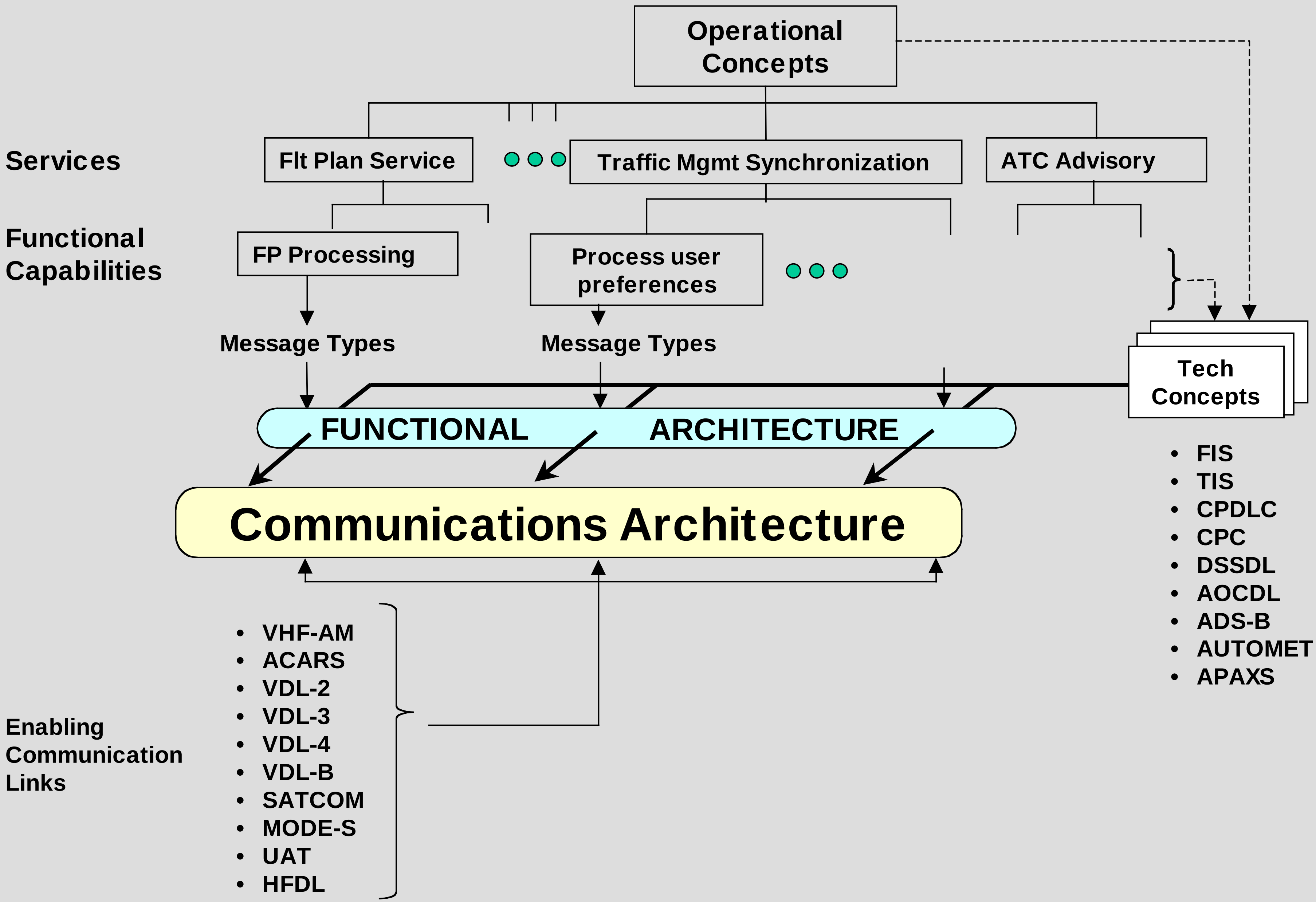
Mature to Present (Top Down)

Benefits Driven (Based on Equipage)

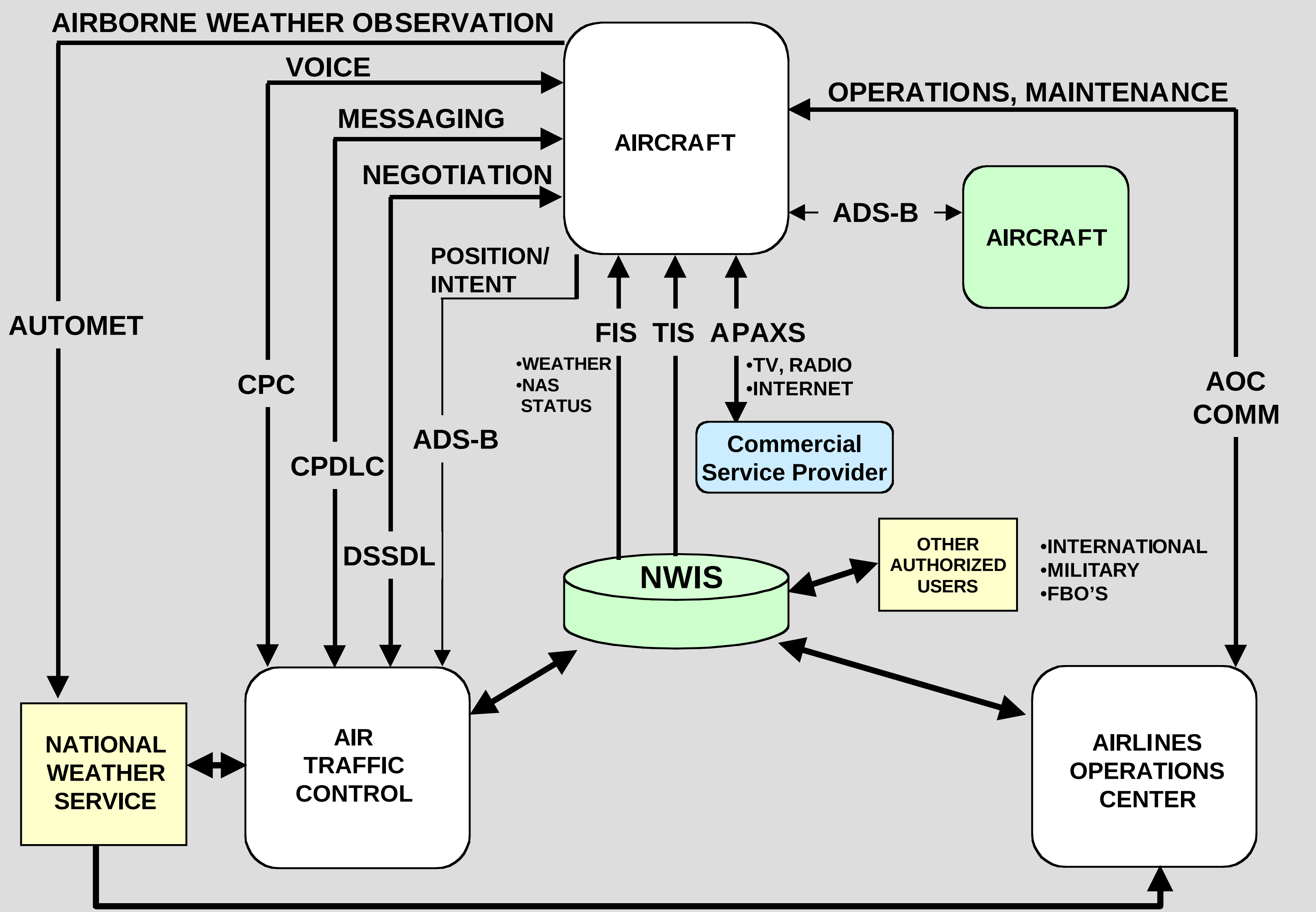
Evolutionary Path

Architecture Selection Challenges

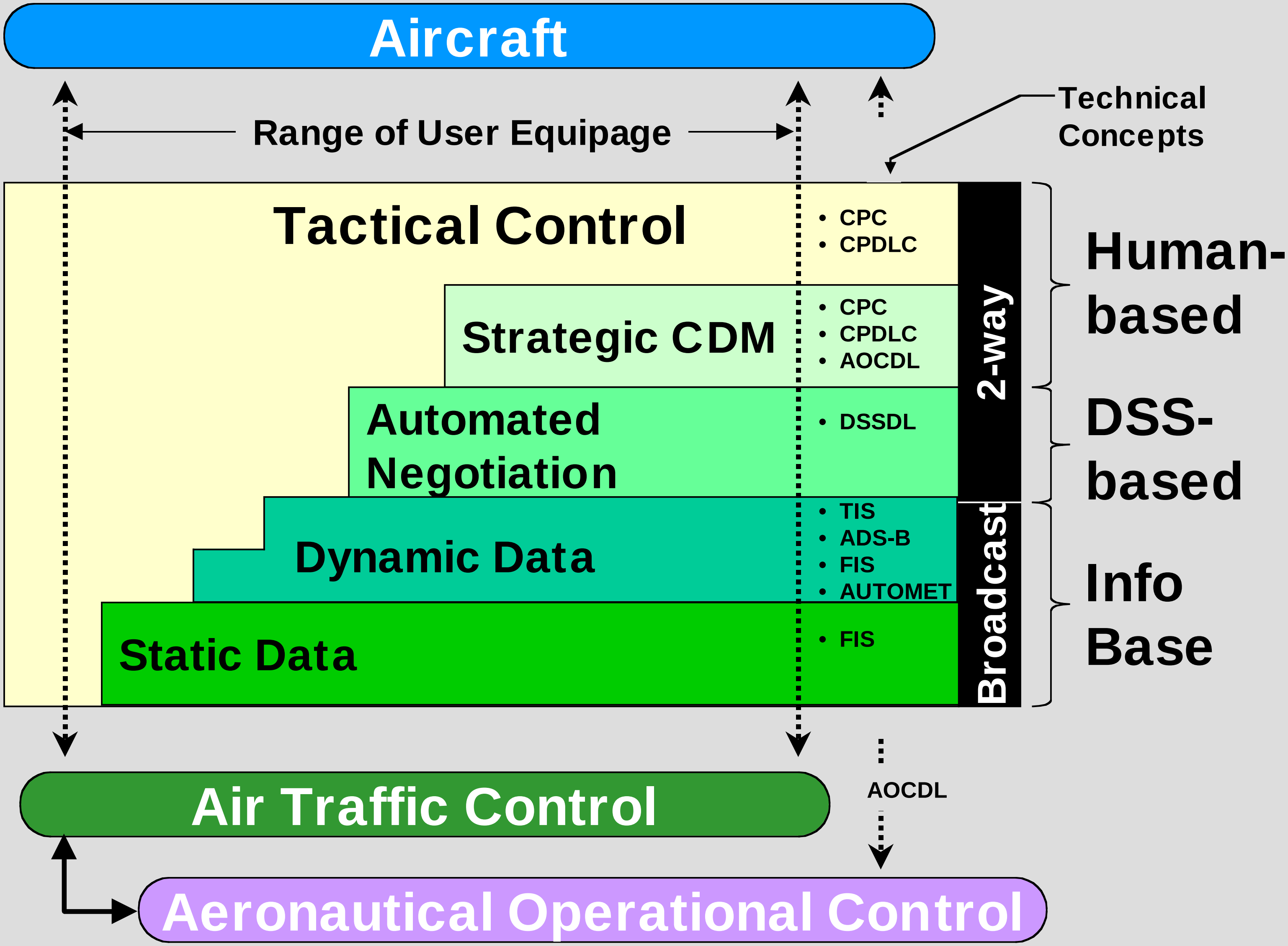
Context for Communication Architecture



Air-Ground Comm Functional Architecture



Benefits Driven Concept



Candidate Architectures

Human / DSS
Concepts
[2 - Way]

Info Base
Concepts
[Broadcast]

NAS
Architectu
re
[VDL]

Space Based
[Broadband
]

Terrestrial
Based
[Broadband]

HYBRIDS

Architecture Selection Drivers

- ✈ **VDL - Planned Network**

- ✈ **Broadband**
  - **Space - Commercial Cabin Services**
  - **Terrestrial - ADS-B Link Decision**

- ✈ **Hybrid - Cost / Schedule / Performance Trades**

Architecture Selection Challenges

✈ **Conflicting Report Data - contributes to load estimate uncertainty**
- **Air Traffic forecasts**
- **Message definition, size, and frequency**

✈ **Selection of Hybrid Architecture should be driven by Cost, Schedule, or Performance considerations**
- **Cost not a consideration for this task**
- **2007 Schedule not a driver - given no cost constraints**
- **Performance - function of a selected link - many unknowns**
  - — **ADS-B link decision - can have major impact on architecture selection**
  - — **SATCOM implementation - driven by commercial cabin services (could lead to class 1 Avionics cost/performance issues)**
  - — **FIS-B implementation - commercial design implementation can drive overall architecture**

Task 5 AATT
2015 Architecture

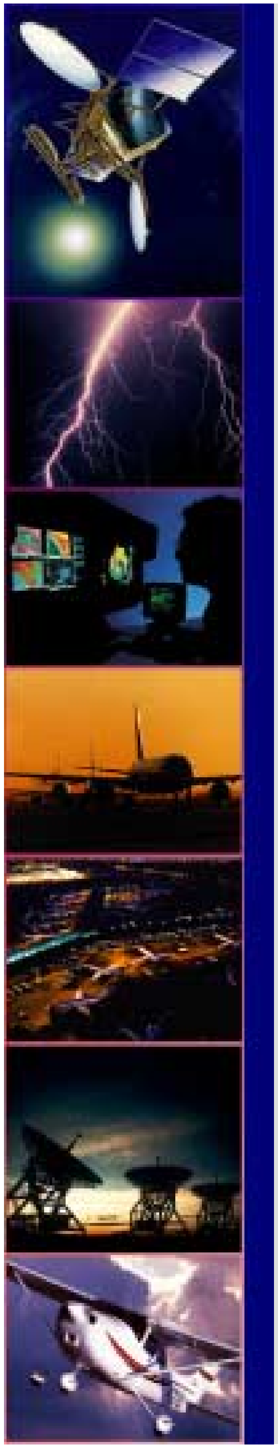
Task 6 AATT
2007 Architecture

Task 7 AWIN
2007
Architecture

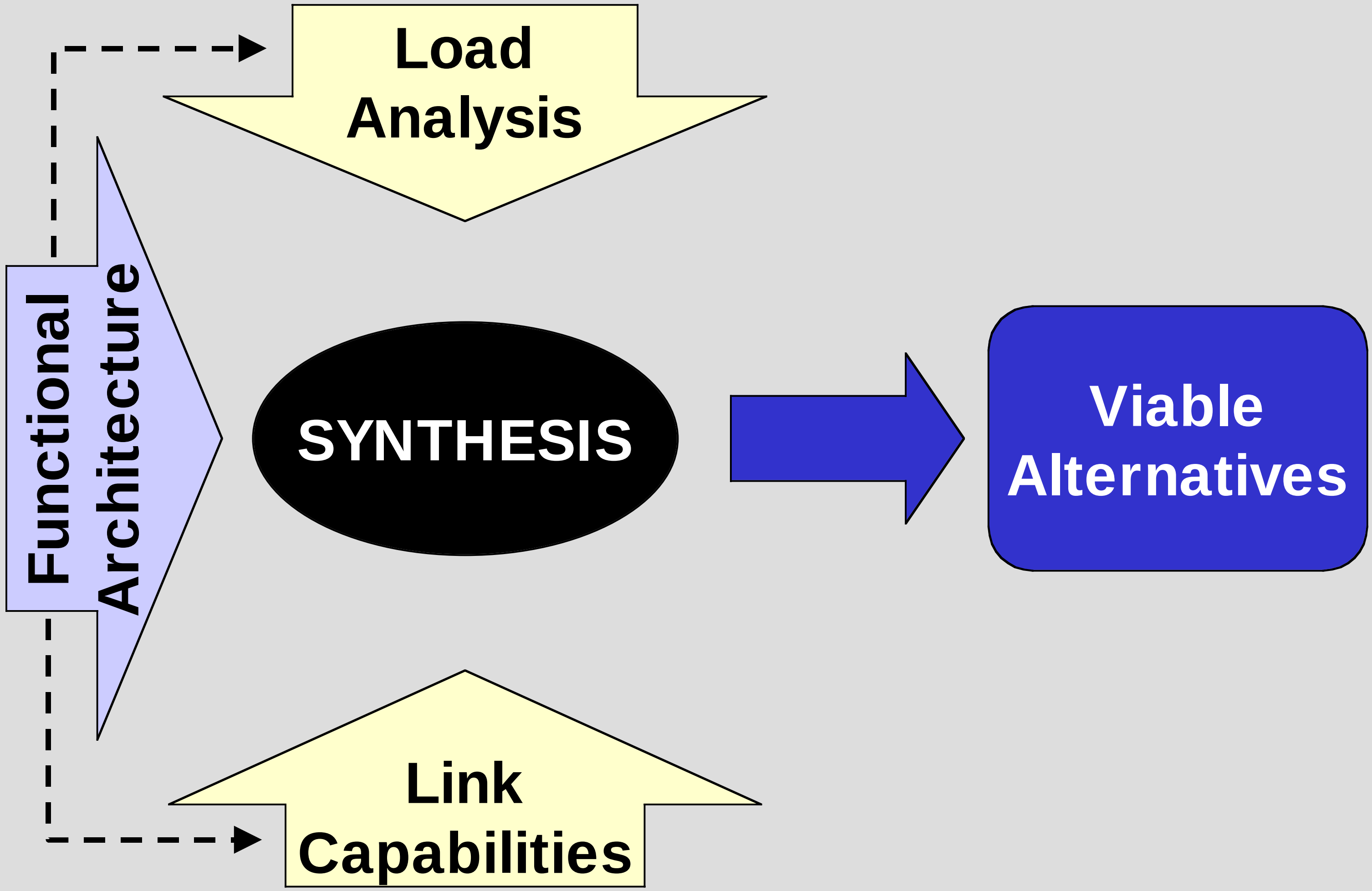
Begin with 2015 Analysis

2015 AATT Mature State Drives 2007 AATT

2007 AWIN analysis conducted in context of 2007



Process


Load
Analysis
Functional
Architecture
SYNTHESIS
Viable
Alternatives
Link
Capabilities

Functional Analysis

- 9 Technical Concepts
- Defined Message categories and message types for each Technical Concept
- Concept Description
- Concept Diagram

Operational Concept - Tech Concept

Operational Concept	Technical Concept
Aircraft continuously receive Flight Information to enable common situational awareness	Flight Information Services (FIS)
Aircraft continuously receive Traffic Information to enable common situational awareness	Traffic Information Services (TIS)
Controller - Pilot messaging supports efficient Clearances, Flight Plan Modifications, and Advisories (including Hazardous Weather Alerts)	Controller-Pilot Data Link Communications (CPDLC)
Controller - Pilot voice communication	Controller Pilot Communications (CPC)
Aircraft exchange performance / preference data with ATC to optimize decision support	Decision Support System Data Link (DSSDL)
Aircraft continuously broadcast their position and intent to enable optimum maneuvering	Automated Dependent Surveillance-Broadcast (ADS-B)
Pilot - AOC messaging supports efficient air carrier/air transport operations and maintenance	Airline Operational Control Data Link (AOCDL)
Aircraft report airborne weather to improve weather nowcasting/forecasting	Automated Meteorological Transmission (AUTOMET)
Passengers enjoy in-flight television, radio, internet, and entertainment service	Aeronautical Passenger Services (APAXS)

Message Categories

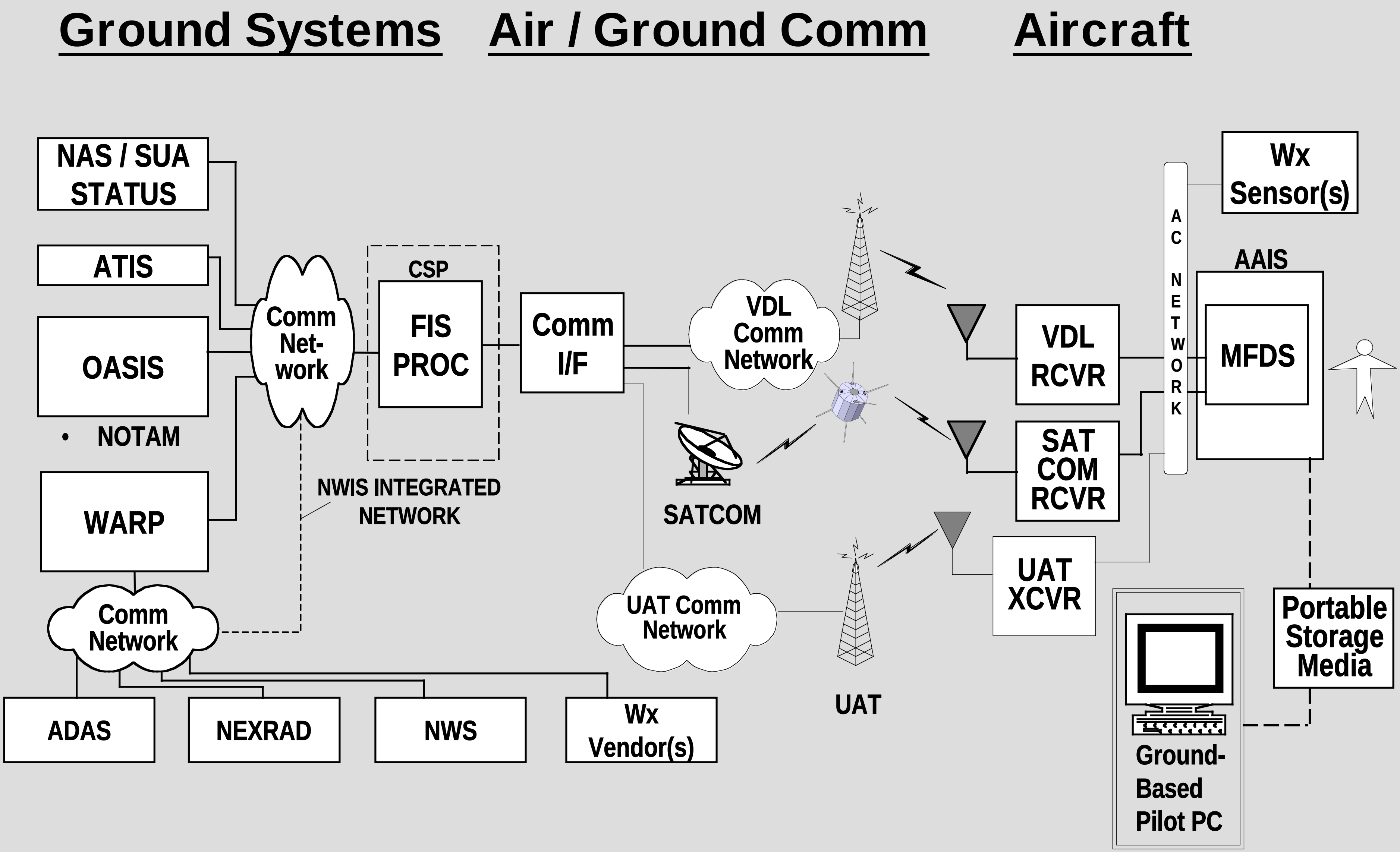
TECHNICAL CONCEPT	Msg Category #	MESSAGE CATEGORY	MESSAGE CONTENT
Flight Information Services (FIS)	1	Flight Information	Dynamic NAS status data and weather data
Traffic Information Services (TIS)	2	Traffic Information	Real time aircraft position data (including trajectory information) provided by ATC.
Controller-Pilot Data Link Communications (CPDLC)	3	Controller – Pilot Messaging	Clearances, Flight Plan Modifications, and Advisories
Controller-Pilot Communications (CPC)	4	Controller – Pilot Voice	Clearances, Flight Plan Modifications, and Advisories
Decision Support System Data Link (DSSDL)	5	Aircraft – ATC Messaging	Aircraft performance / preference
Airline Operational Control Data Link (AOCDL)	6	Aircraft-AOC Messaging	Air carrier / air transport operations and maintenance
Automated Dependent Surveillance-Broadcast (ADS-B)	7	ADS Reporting	Aircraft continuously broadcast their position and intent
Automated Meteorological Transmission (AUTOMET)	8	Aircraft Weather Reporting	Aircraft report airborne weather (wind velocity/magnitude, temperature, humidity)
Aeronautical Passenger Services (APAXS)	9	Passenger Services	In-flight television, radio, and entertainment services including internet services

Concept Description - Flight Information Service

- **Aircraft continually receive dynamic Flight Information to enable common situational awareness**
  - **Weather Information**
  - **NAS Status**
  - **NAS Traffic Flow Status**

Note: We assume that static data will be loaded on aircraft via portable storage media prior to flight.

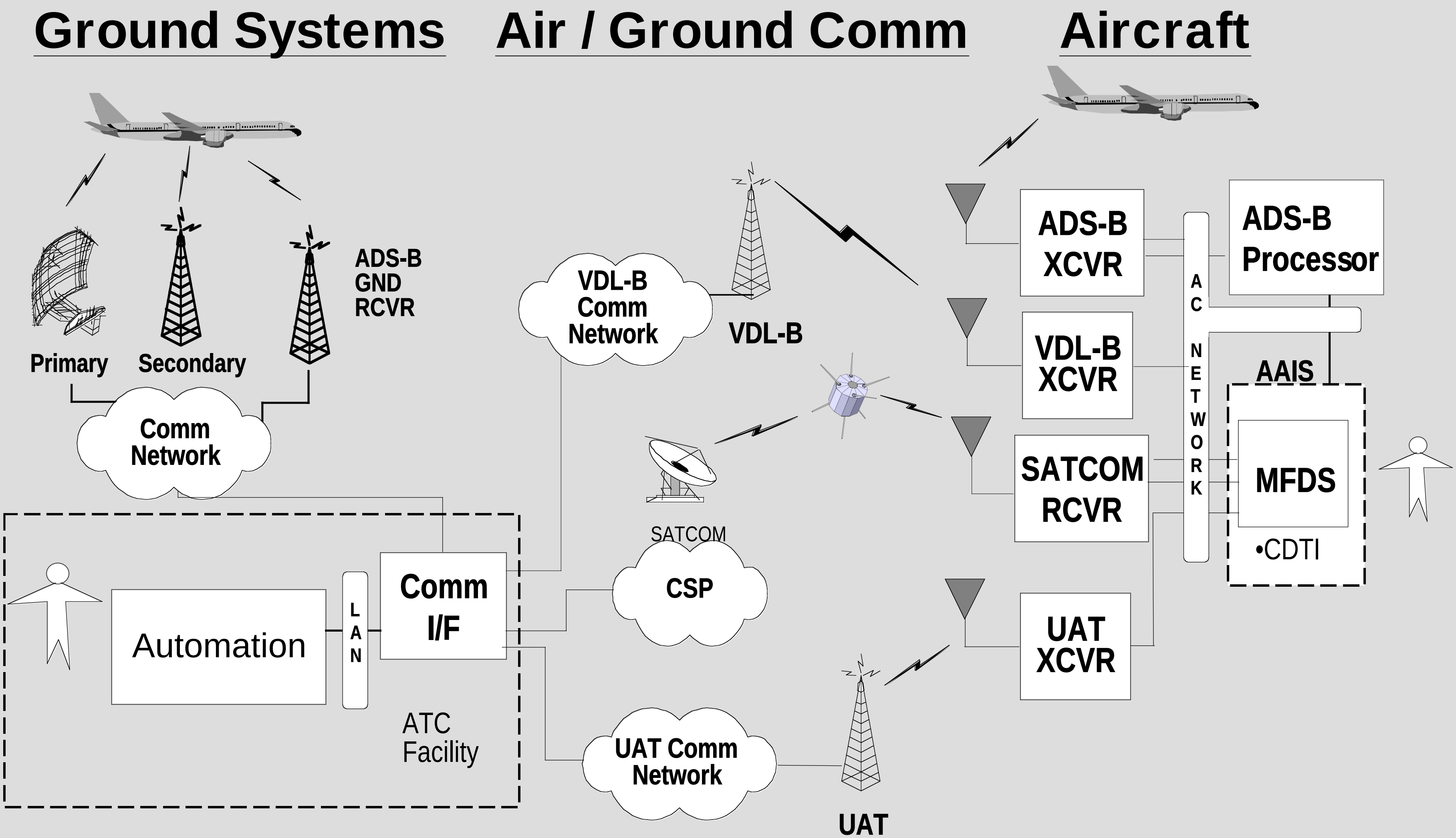
2015 Flight Information Service - FIS



Concept Description - Traffic Information Service

- **Aircraft continually receive dynamic Traffic Information data to enable common situational awareness (air, ground)**
  - **Traffic Information combined with air-air ADS-B data and displayed on CDTI**
    - **Tactical Maneuvering - close proximity traffic**
    - **Strategic Trajectory Planning**
- **Real time aircraft position data received by ATC from the ground-based surveillance sensor network.**
  - **ATC combines received aircraft position data with trajectory and intent data and then broadcasts to participating aircraft.**

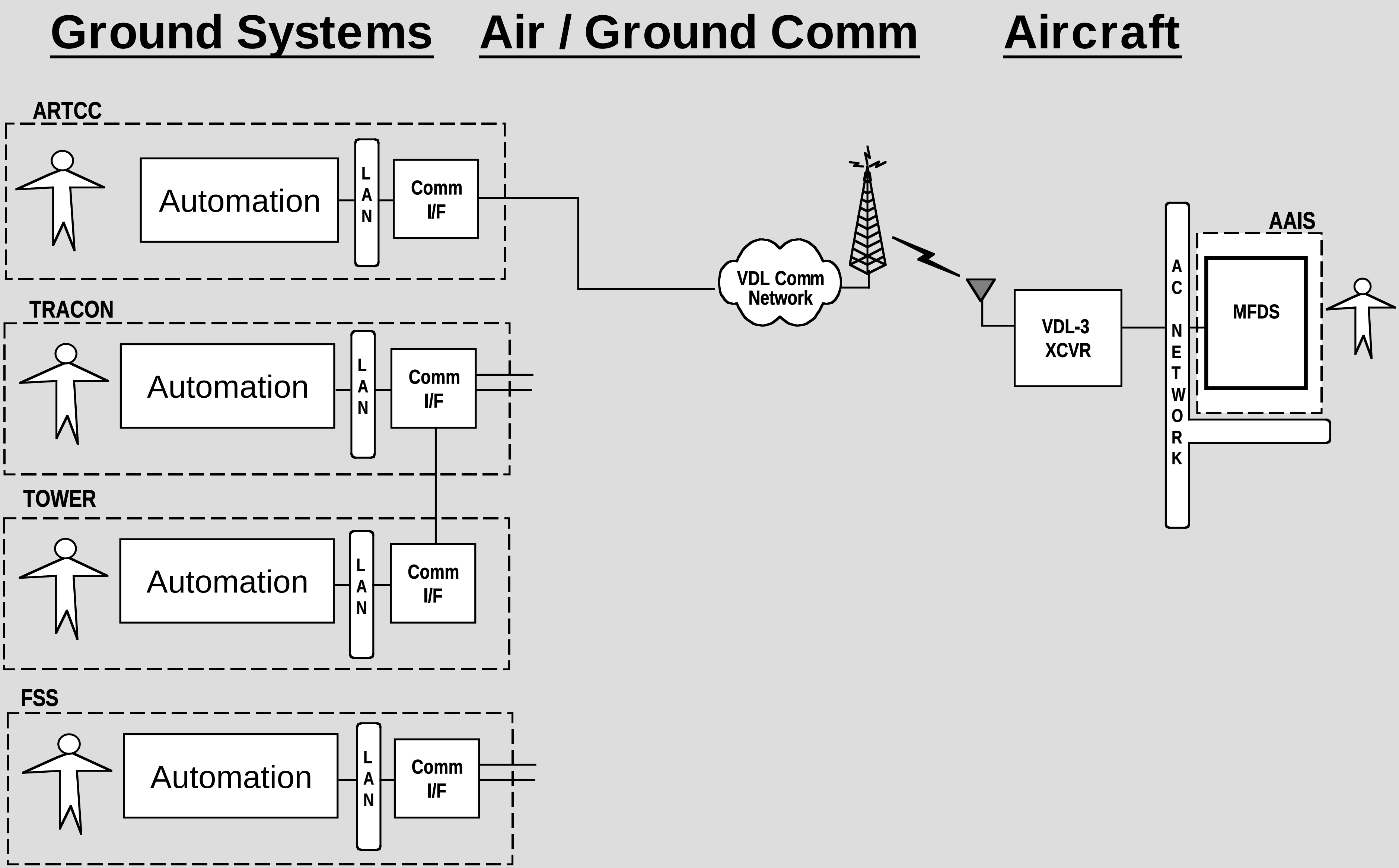
2015 TIS
Traffic Information Services



Concept Description - Controller/Pilot Data Link Communication

- Controller - Pilot exchange data messages to reduce voice frequency congestion and provide a more precise and efficient means of communicating instructions and requests.
- Messages support efficient clearances, flight plan modifications, and advisories for tactical control and strategic CDM.
- CPDLC messages are ATN compliant, which accommodates message prioritization. Fixed or free-text messages are supported.

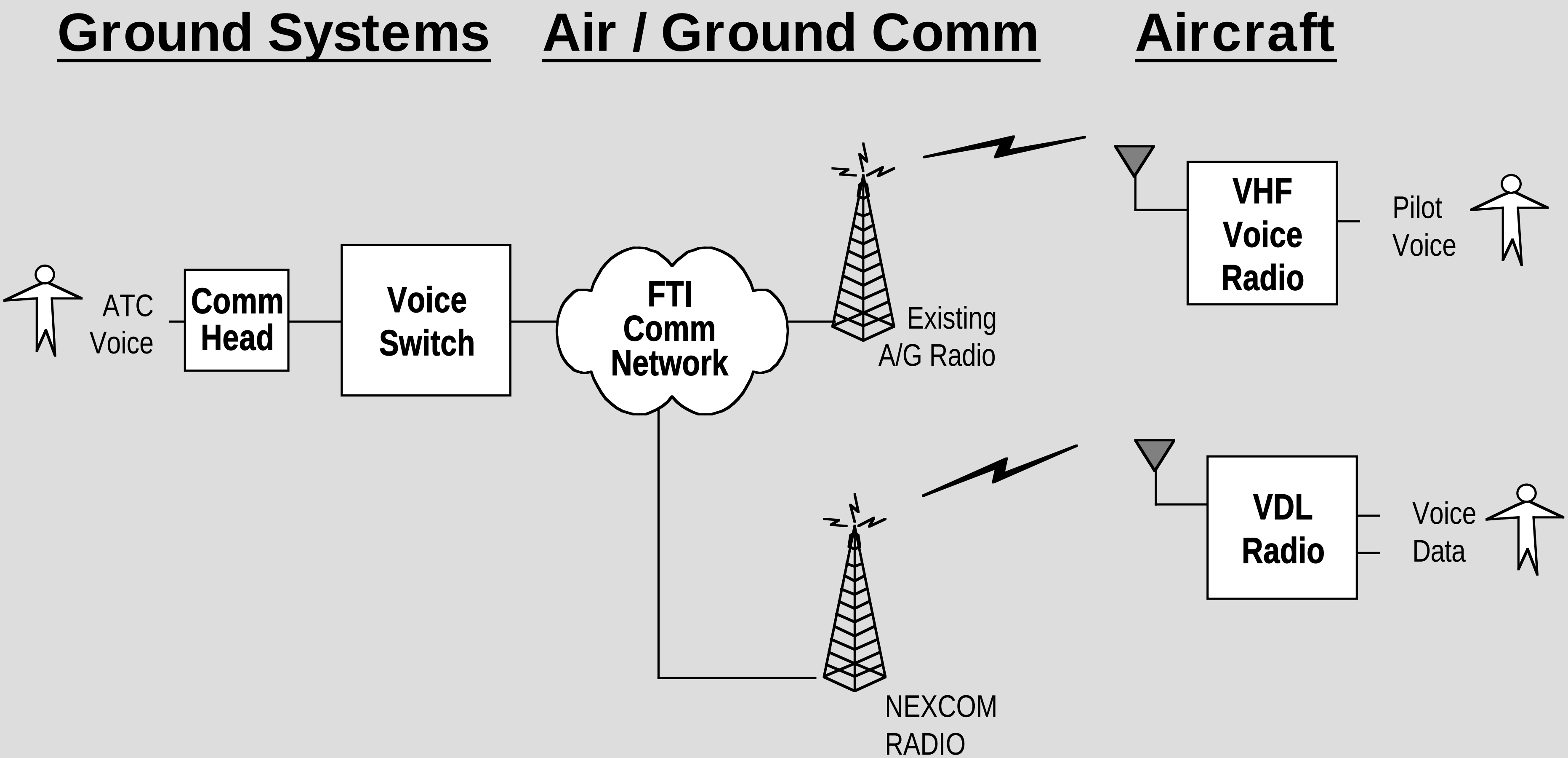
2015 CPDLC
Controller / Pilot Data Link Communications



Concept Description - Controller/Pilot Voice Communication

- CPC supports tactical control and strategic CDM.
- CPC communication remains the foundation of air traffic control.
- It is critical to maintain a high quality, robust voice communication service.
- Digitized voice service can be combined with data service provided QOS is maintained

2015 - CPC Controller/Pilot Voice Communication

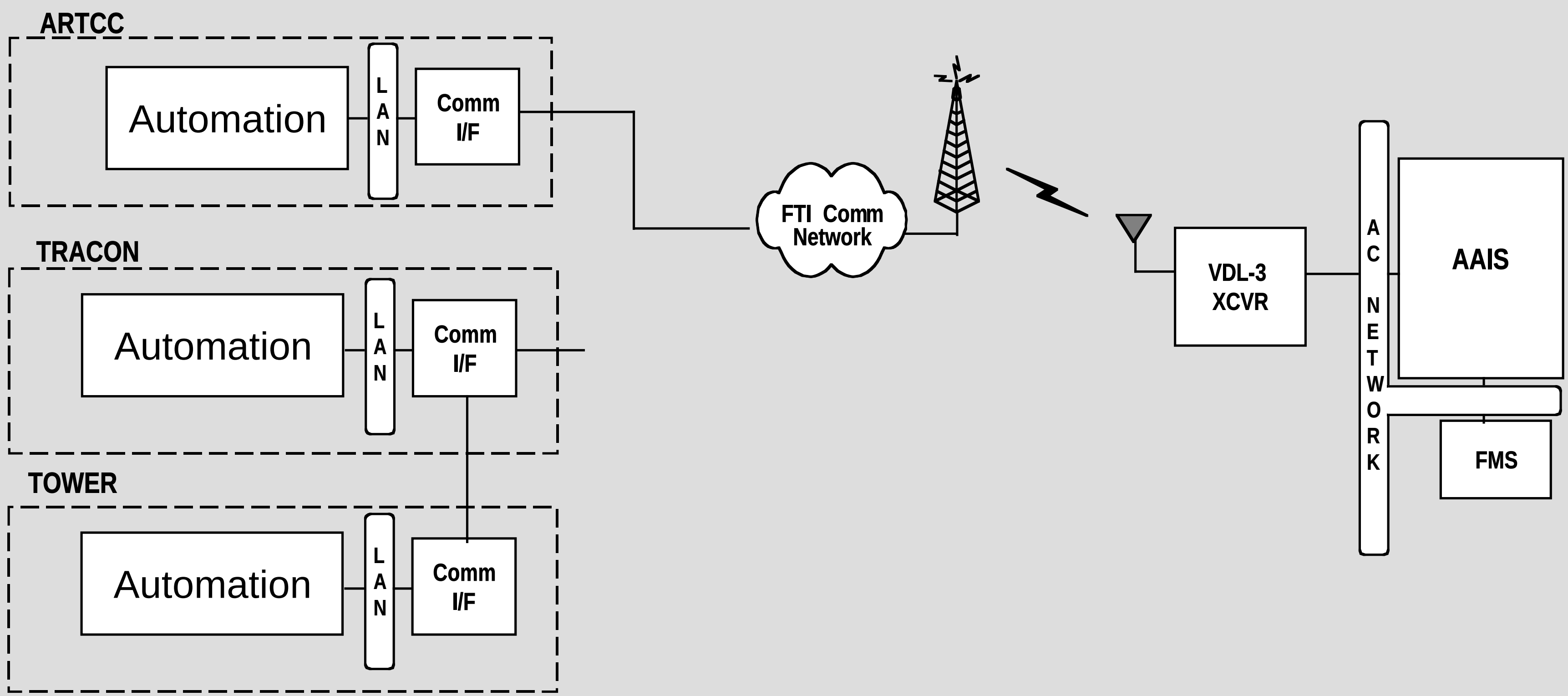


Concept Description - Decision Support System Data Link

- Aircraft exchange performance / preference data to optimize flight operation
  - with ATC
  - with other aircraft
- Supports calculations by ATC and Aircraft DSS algorithms that provide input to controllers and pilots
- Does not require human intervention or acknowledgement

2015 DSSDL
Decision Support System Data Link

Ground Systems   Air / Ground Comm   Aircraft

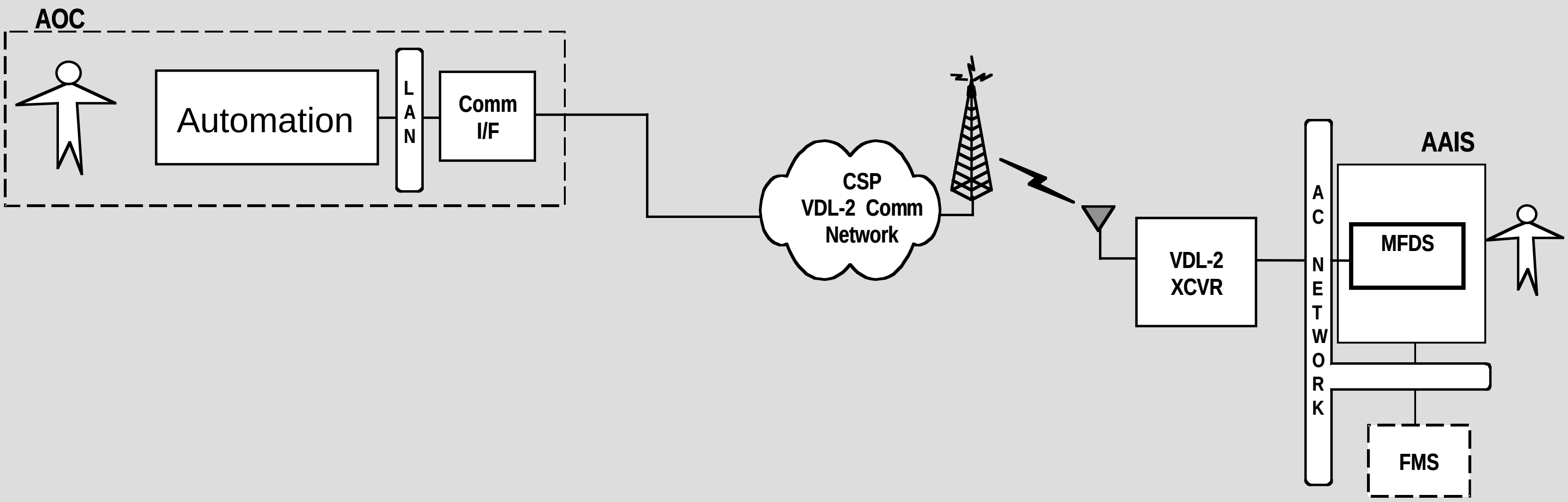


Concept Description - Aeronautical Operation Center Data Link

- Pilot - AOC messaging supports efficient air carrier/air transport operations and maintenance.
- AOCDL allows the dispatcher to conduct individual flights (and the entire schedule) efficiently to enhance the business success and profitability of the airline.
- Most major airlines operate a centralized AOC function at an operations center that is responsible for worldwide operations.
- Supports data exchange for strategic CDM between pilot/aircraft and AOC

2015 AOCDL
Aeronautical Operational Control Data Link

Ground Systems **Air / Ground Comm** **Aircraft**

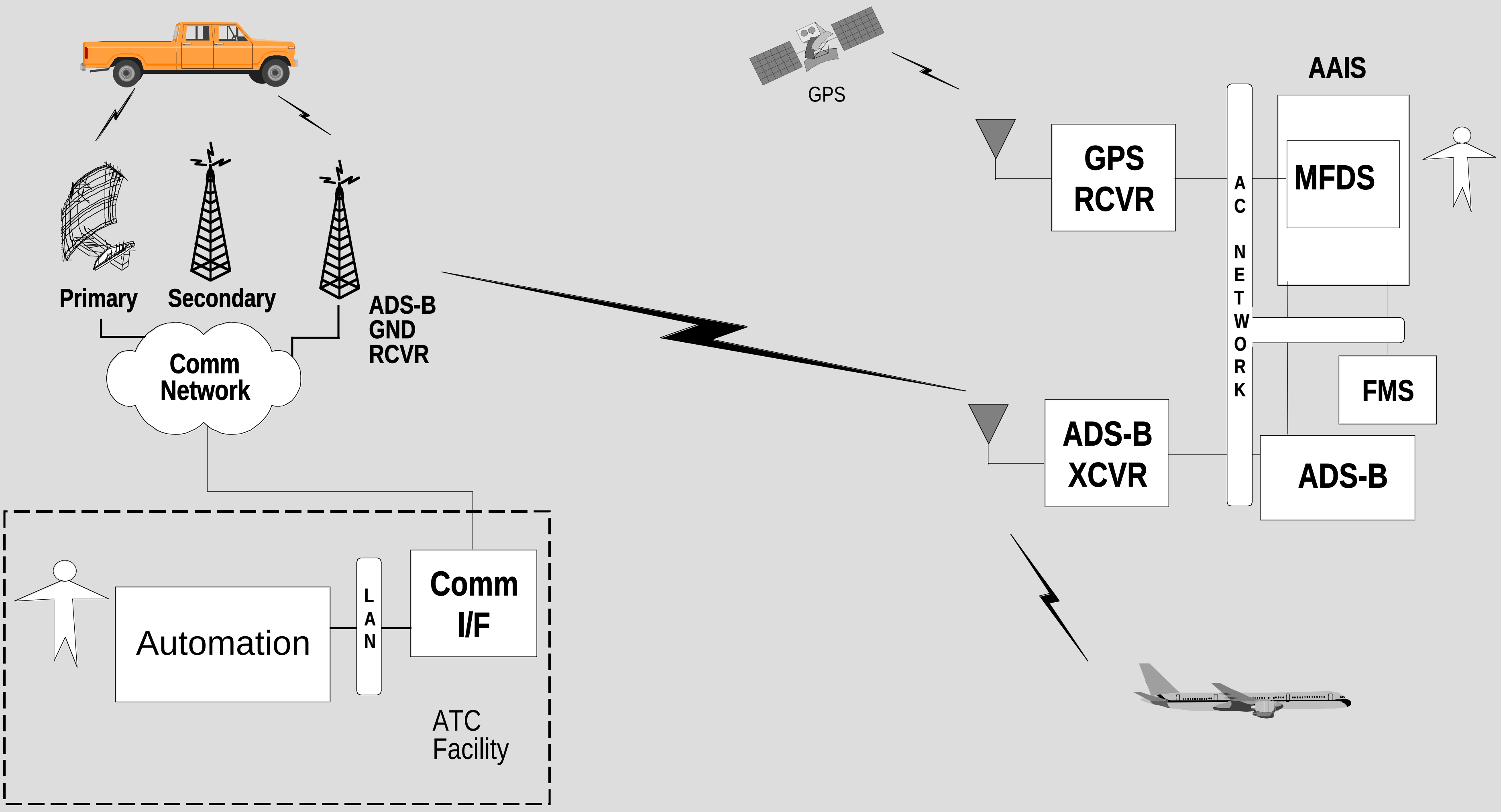


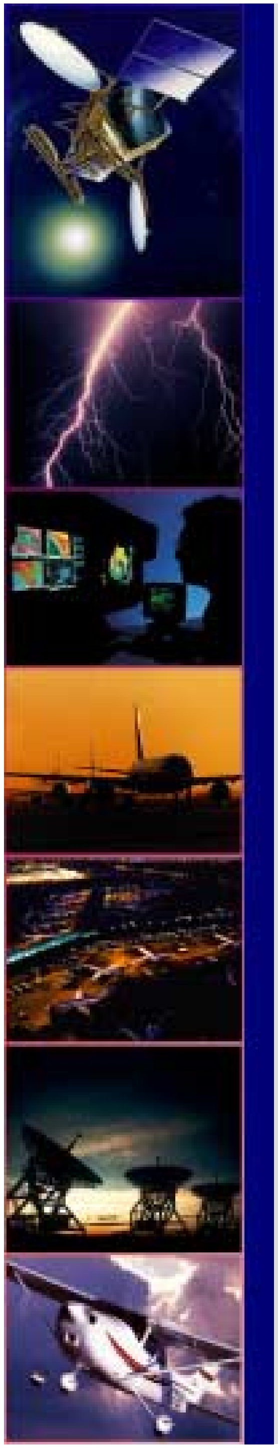
Concept Description - Automatic Dependent Surveillance - Broadcast

- Aircraft continuously broadcast dynamic traffic information data to enable optimum maneuvering
- Traffic information consists of position, velocity, and intent information using GPS as the primary source of navigation data to
  - aircraft
  - surface vehicles
- Supports
  - air-air pair-wise maneuvers
  - approach maneuvers
  - extended separation services
  - surface separation services

2015 ADS-B
Automatic Dependent Surveillance - Broadcast

Ground Systems   Air / Ground Comm   Aircraft





Concept Description - Aeronautical Passenger Services

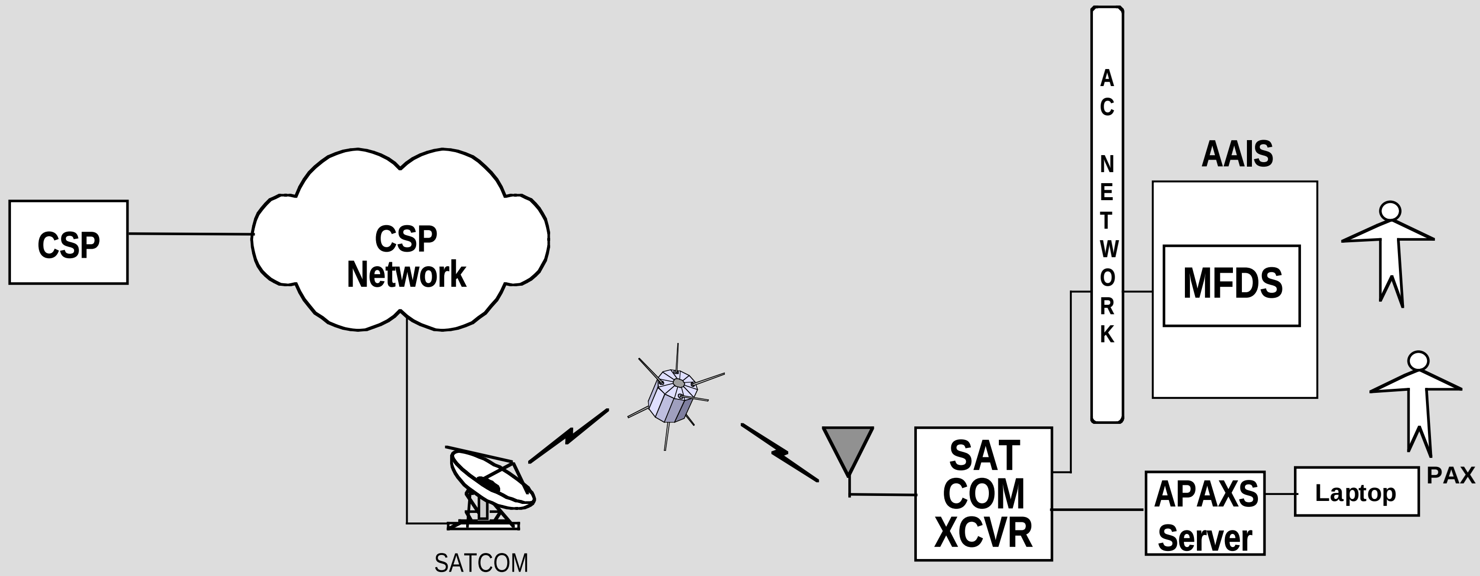
- Commercial service providers supply in-flight television, radio, telephone, entertainment, and internet service.

- Assumed SATCOM only in en route domain

  This was included because of potential for infrastructure support to ATC service

2015 APAXS
Aeronautical Passenger Services

Ground Systems   Air / Ground Comm   Aircraft



- TV
- Audio
- Entertainment
- Phone
- Internet

Concept Description - Automated Meteorological Transmission

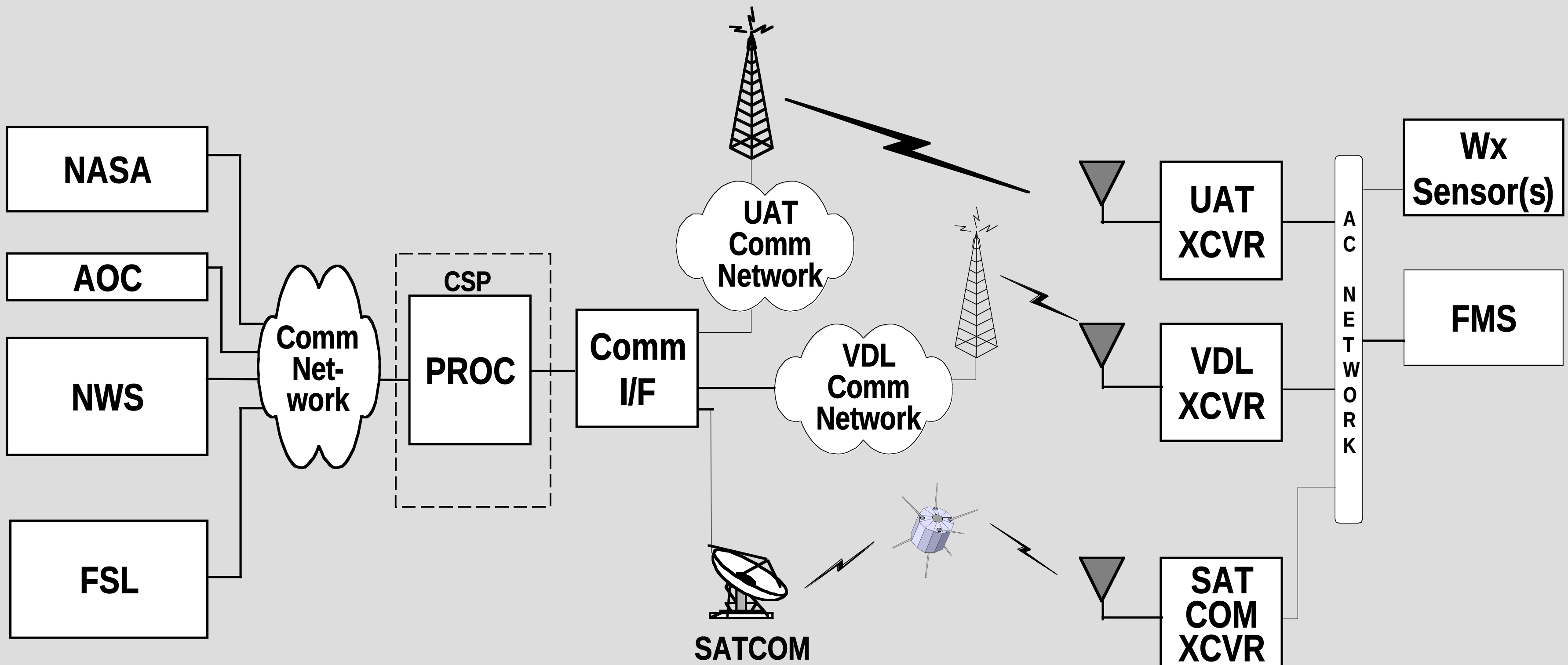
- ✈Aircraft report airborne weather data to improve weather nowcasting/forecasting.

  Also know as...
  - MDCRS, E-MDCRS [NOAA, NWS]
  - ACARS [NOAA, FSL]
  - EPIREPS [NASA]

- ✈AUTOMET definition is currently under the auspices of the RTCA SC 195
  - ✈Minimum Interoperability Standards (MIS) for Automated Meteorological Transmission (RTCA DO-252)
  - ✈wind, temperature, water vapor and turbulence.

Automated Meteorological Transmission - AUTOMET

Ground Systems | Air / Ground Comm | Aircraft



2015 Link Summary

Data Link	Single Channel Data Rate	Capacity for Aeronautical Communications	Channels Available to Aircraft	# Aircraft Sharing Channel (Expected Maximum)	Comments
	kbps	Channels	Channels	Aircraft	
HFDL	1.8	2	1	50	Intended for Oceanic
ACARS	2.4	10	1	25	ACARS should be in decline as users transition to VDL Mode 2
VDL Mode 2	31.5	4+	1	150	System can expand indefinitely as user demand grows
VDL Mode 3	31.5*	~300	1	60	Assumes NEXCOM will deploy to all phases of flight
VDL Mode 4	19.2	1-2	1	500	Intended for surveillance
VDL – B	31.5	2	1	Broadcast	Intended for FIS
Mode-S	1000**	1	1	500	Intended for surveillance
UAT	1000	1	1	500	Intended for surveillance/FIS
SATCOM	-	-	-	-	Assumes satellites past service life
Future SATCOM	384	15	1	~200	Planned future satellite
Future Ka Satellite	2,000	~50	~50	~200	Estimated capability - assumes capacity split for satellite beams
Fourth Generation Satellite	>100,000	>100	>100	Unknown	Based on frequency license filings

* Channel split between voice and data.

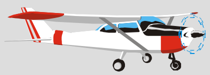
** The Mode-S data link is limited to a secondary, non-interference basis with the surveillance function and has a capacity of 300 bps per aircraft in track per sensor (RTCA/DO-237).

Load Analysis

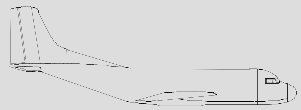
- ✈Established Data Set (Task 1,2,3 Msg. Characteristics, performance requirements)
- ✈Defined User Classes
- ✈Defined Equipage Forecast
- ✈Defined Domains
- ✈Defined Assumptions
- ✈Method of Calculation
- ✈Load Analysis Results

Load Analysis - User Classes

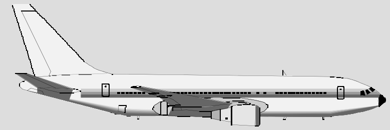
Class 1



Class 2



Class 3



Class of Aircraft	Definition and Comment
Class 1	Operators who are required to conform to FAR Part 91 only, such as low-end General Aviation (GA) operating normally up to 10,000 ft. This class includes operators of rotorcraft, gliders, and experimental craft and any other user desiring to operate in controlled airspace below 10,000 ft. The primary distinguishing factor of this class is that the aircraft are smaller and that the operators tend to make minimal avionics investments.
Class 2	Operators who are required to conform to FAR Parts 91 and 135, such as air taxis and commuter aircraft. It is likely that high-end GA and business jets and any other users desiring to operate in controlled airspace will invest in the necessary avionics to be able to achieve the additional benefits.
Class 3	Operators who are required to conform to FAR Parts 91 and 121, such as Commercial Transports. This class includes passenger and cargo aircraft and any other user desiring to operate in controlled airspace. These users will invest in the avionics necessary to achieve the additional benefits.

Load Analysis - Equipage Forecast (%)

	2015						
	CPC	CPDLC	DSSDL	ADS-B / TIS	FIS / AUTOMET	APAXS	AOCDL
Class 1	100	48	10	53	52	2	0
Class 2	100	76	34	65	74	3	5
Class 3	100	98	70	90	79	46	51

	2007 (30% of 2015 for CPDLC, DSSDL, ADS-B/TIS, APAXS and 70% of 2015 for FIS/AUTOMET, and 100% of AOCDL)						
	CPC	CPDLC	DSSDL	ADS-B / TIS	FIS / AUTOMET	APAXS	AOCDL
Class 1	100	14	3	16	16	1	0
Class 2	100	23	10	20	22	1	5
Class 3	100	29	21	27	24	14	51

Estimate based on 1999 FAA forecast

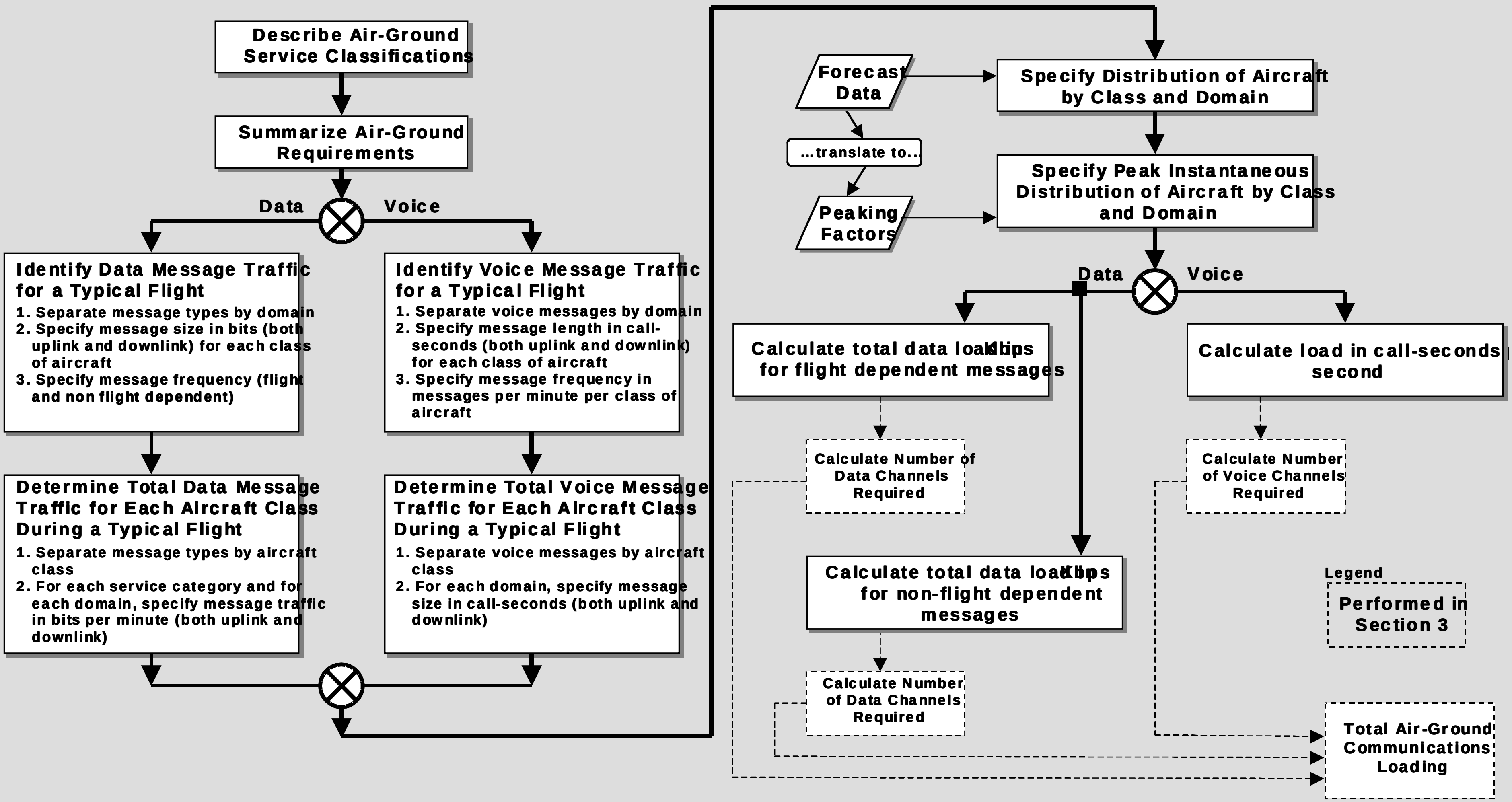
Domain Definitions

Domain	Definition and Comment
En route	Airspace in which en route air traffic control services are normally available. The average flight duration is 25 minutes per en route center.
Terminal	Airspace in which approach control services are normally available. The average flight duration is 10 minutes.
Airport	Airspace, including runways and other areas used for taxiing, takeoff, and landing, in which tower control services are normally available. The average flight duration is 10 minutes.
Oceanic	Airspace over the oceans of the world, considered international airspace, where oceanic separation and procedures per the International Civil Aviation Organization are applied. The average flight duration is 180 minutes.

Load Analysis - Assumptions

- Use of CSP is acceptable for all services provided QOS can be satisfied
- Ground and Airborne processing and storage capacities are sufficient that they are not considered a factor
- 8 bits per character is used to convert messages size in characters to message size in bits.
- ATN protocol overheads are applied to all connection oriented messages, i.e., CPDLC, DSSDL, AOCDL, and AUTOMET messages, plus all flight dependent FIS messages.
- ATN protocol overhead varies according to message context and message size
- Non-flight dependent FIS messages and all TIS messages include an overhead of 10% for error detection and synchronization.
- Modulation efficiency for D8PSK is assumed to be 1.25 bps per Hertz
- All AUTOMET traffic is suppressed in the airport domain to reduce channel requirements
- Class 1 and Class 2 aircraft will not subscribe to APAXS
- SATCOM links provide CONUS coverage

Method of Calculation



FIS Products

Primary Source: Data Communications Requirements, Technology and Solutions for Aviation Weather Information Systems (Phase I Report), Lockheed Martin Aeronautical Systems 1999.

Assumptions:

- Projected weather products are bit-mapped pictures in a multi-dimensional grid.
- Broadcast weather products represent computer generated, synthesized, integrated information.
- These products represent generic projections of products that will be available five to 10 years in the future.

Secondary Source: RTCA DO 237, Aeronautical Spectrum Planning, 1997

2015 FIS Message Set

Msg ID (M#)	Message Category	Definition/Comment	Source (1)
M15	Convection	Includes data regarding cloud tops, freezing level, lightning activity, projected decay, water content, etc.	33
M17	Departure ATIS	Automatic Terminal Information Service (Airport Domain)	80
M18	Destination Field Conditions	Combination of text, icons, and graphics potentially describing NOTAM information, RCR readings, ramp snow conditions, de-icing necessity, arrival rates, etc.	33
M20	En Route Strategic General Imagery	Backup for synthesized weather products or for direct imagery requirement. Examples include satellite photos, lightning strike data, hand drawn surface analysis.	33
M21	FIS Planning - ATIS	Automatic Terminal Information Service (Terminal Domain)	80
M22	FIS Planning Services	Includes real-time weather advisories and warnings	80
M26	General Hazard	A general hazard product would likely include weather hazards in addition to other known hazards (traffic, terrain..)	33
M27	Icing (Terminal Tactical)	May not be practical, difficult to implement. Would depend on automatic reports from in flight aircraft to a central ground location for constant plotting, updating and reporting.	33
M28	Icing/ Flight Conditions (En Route Far Term, Near Term Strategic, Tactical)	IMC and icing are included in this product aimed at GA.	33
M29	Low Level Wind Shear (Terminal Tactical)	This product may identify dangerous shearing winds caused by microbursts, frontal passage, etc. Generated from ground-based sensors, fused with NEXRAD or TDWR data to create a near-ground level view.	33
M35	Radar Mosaic	Real-time broadcasts of NEXRAD or TDWR-type RADAR pictures in the terminal area.	33
M37	Surface Conditions (En Route Far Term Strategic)	This product will project surface conditions to enhance situational awareness and support contingency planning	33
M39	Turbulence (En Route Far Term and Near Term Strategic, En route Tactical)	Strategic Turbulence information will become one of the most important future products. A true tactical product may not be feasible but future product may combine current sensed condition with next available nowcast.	33
M40	Winds/Temperature (En Route Far Term and Near Term Strategic)	This product contains information on Enroute winds and temperatures	33

Note: (1) Source 33 is the Data Communications Requirements, Technology and Solutions for Aviation Weather Information Systems (Phase I Report), Lockheed Martin Aeronautical Systems 1999
Source 80 is RTCA DO 237, Aeronautical Spectrum Planning, 1997

2015 FIS Load Analysis Results

2-way

- Worst case scenario: En Route airspace with high density Terminal area and four major Airports

	Airport	Terminal	En Route	Total
FIS - Domain	36.4	135	1092	
Region (x) [1]	145.6 (4)	135 (1)	1092 (1)	1372.6

Note: (x) is domain multiplier (K-bits per second)

Broadcast

- Regional scenario: En Route airspace with 5 Terminal/Airport areas

	Airport	Terminal	En Route	Total
FIS - Domain	0.2	0.9	6.9	
FIS - Region	1.0 (5)	4.5 (5)	6.9 (1)	12.4
FIS - National				248 (20)

Note: (x) is domain multiplier (K-bits per second)

2015 FIS Viable Alternatives

- ✈ **Broadcast is preferable for FIS**
- ✈ **VDL-B can support a regional broadcast of FIS data**
  - **Allocation of only 2 frequencies per CSP poses coverage / interference problems for National implementation**
- ✈ **UAT, SATCOM can support Regional and National implementation**

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft continuously receive Flight Information to enable common situational awareness	FIS					✓		✓	✓	
✓ Acceptable Alternative		☐ NAS Architecture				★ Restricted Operation				

2015 TIS Load Analysis Results

TIS Message

Message Type	Message Identifier	Message Category
2	M3	Air Traffic Information

- **ID, Position, Intent**

Broadcast

✈Traffic Information by Domain **(K-bits per second)**

	Airport	Terminal	En Route	Total
TIS - Domain	23.7	7.0	20.5	
TIS - Regional	N/A	35.0 (5) [1]	20.5	55.5
TIS - National	N/A	58.5 [1139] [2]	170 [4140]	228.5

Note 1: Region defined as 1 En Route, 5 Terminal

Note 2: National Peak Total number of aircraft per domain

2015 TIS Viable Alternatives

- TIS is assumed broadcast
  - ATN message overhead on VDL 2-way links makes them undesirable for TIS data
- VDL-B can support domain broadcast of TIS data
  - Requires dedicated frequency for each domain so not viable until after NEXCOM implementation
- Mode-S is current NAS Architecture solution
  - Cannot support broadcast load requirement for our concept of TIS (tactical and strategic)
- UAT, SATCOM can support Regional and National broadcast

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft continuously receive Traffic Information to enable common situational awareness	TIS					3		3	3	

3 Acceptable Alternative   NAS Architecture (empty box)   ★ Restricted Operation

2015 CPDLC Load Analysis Results

CPDLC Messages

Msg ID	Message Type
M32	Pilot/ Controller Communications
M34	Pre-Departure Clearance
M41	System Management and Control

Result Summary:
Single VDL-3 sub-channel can conservatively support 4.8 kbps of data.

	Airport	Terminal	En Route
CPDLC- Domain	6.3	2.2	2.4
CPDLC – (Estimate per Sector)	1.6 (4)	0.3 (7)	0.1 (20)

2015 CPDLC Viable Alternatives

- ✈VDL-3 is the NAS Architecture solution for CPDLC
  - – Easily supports load requirements

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Controller - Pilot messaging supports efficient Clearances, Flight Plan Modifications, and Advisories (including Hazardous Weather Alerts)	**CPDLC**			✓						

✓ Acceptable Alternative ☐ NAS Architecture ★ Restricted Operation

2015 CPC Load Analysis Results

- In 2015 most routine messages are sent via CPDLC
  - Clearance Delivery
  - Transfer of Communication
  - Initial contact
  - Altimeter
- Our Analysis assumed an average of 1.5 call-seconds per minute per flight

Class	Airport		Terminal		En Route	
	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink
1	2.7	1.3	0.7	0.7	2.0	0.5
2	0.9	0.4	0.3	0.3	0.2	0.1
3	1.2	0.5	0.0	0.0	0.0	0.0
Total	7.0		1.9		2.7	
Voice Channels Required (P=0.2)	8		3		4	

Call-seconds per second

2015 CPC Viable Alternatives

✈Our communication load analysis indicates that a single VDL-3 sub-channel is sufficient to support controller pilot communication under worst case loading conditions.

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Controller - Pilot voice communication	CPC	✓		✓						
✓ Acceptable Alternative		☐ NAS Architecture				★ Restricted Operation				

2015 DSSDL Load Analysis Results

DSSDL Messages

Msg ID (M#)	Message Type
M2	Advanced ATM
M16	Delivery of Route Deviation Warnings
M38	TFM Information

Result Summary:
Single VDL-3 sub-channel can conservatively support 4.8 kbps of data.

	Airport	Terminal	En Route
DSSDL – Domain	0.5	0.3	0.2
DSSDL – (Estimated by Sector)	0.1 (4)	0.1 (7)	0.1 (20)

2015 DSSDL Viable Alternatives

- ✈ **VDL-3 is the NAS Architecture solution for DSSDL**
  - **Easily supports load requirements**

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft exchange performance / preference data with ATC to optimize decision support	**DSSDL**			✓						

✓ Acceptable Alternative | ☐ NAS Architecture | ★ Restricted Operation

2015 AOCDL Message Set

Msg ID (M#)	Message Type
M8	Airline Maintenance Support: Electronic Database Updating
M9	Airline Maintenance Support: In-Flight Emergency Support
M10	Airline Maintenance Support: Non-Routine Maintenance/ Information Reporting
M11	Airline Maintenance Support: On-Board Trouble Shooting (non-routine)
M12	Airline Maintenance Support: Maintenance/ Information Reporting
M19	Diagnostic Data
M23	Flight Data Recorder
M25	Gate Assignment
M30	Out/ Off/ On/ In
M33	Position Reports

2015 AOCDL Load Analysis Results

- ✈ **Worst case scenario: En Route airspace with high density Terminal area and four major Airports**

	Airport	Terminal	En Route	Total
AOCDL	8.8	9.1	3.7	
Worst Case	35.2 (4) [1]	9.1 (1)	3.7 (1)	48

Note: (x) is domain multiplier

(K-bits per second)

2015 AOCDL Viable Alternatives

- VDL-2 national network operated by CSP since 2001
- VDL-2 single frequency effective data rate is 19.2 kbps.
  - 4 frequencies used for AOCDL - 76.8 kbps
  - This is sufficient to support the projected demand
- UAT, SATCOM could support the load requirement
  - Unlikely use if existing network can support requirement

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Pilot - AOC data exchange supports efficient air carrier/air transport operations and maintenance	AOCDL		3					3		3
3 Acceptable Alternative		NAS Architecture								

2015 ADS-B Load Analysis Results

- **ADS-B messages containing identification, state vector, intent, status and other information are assembled by aircraft avionics.**

	Airport	Terminal	En Route	Total
ADS-B	16.1	3.3	1.5	20.9

- **Data transmitted**
  - **Airport - 192 transmitters, 1 message per 1.1s**
  - **Terminal - 137 transmitters, 1 message per 5.3s**
  - **En Route - 500 transmitters, 1 message per 12.1s**

2015 ADS-B Viable Alternatives

- ✈ADS-B link evaluation currently underway - decision in 2001
  - – Mode-S, VDL-4, and UAT
  - – SF-21 trials evaluating all links
- ✈Mode-S is current NAS Architecture solution

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft continously broadcast their position and intent to enable optimum maneuvering	ADS-B				✓		✓	✓		
✓ Acceptable Alternative		☐ NAS Architecture				★ Restricted Operation				

2015 AUTOMET Load Analysis Results

- **AUTOMET message contains**
  - **Wind**
  - **Temperature**
  - **Humidity**
  - **Turbulence**
- **Message size and frequency based on 1999 RTCA MIS**
- **Assume no AUTOMET in Airport Domain**
- **Worst case scenario: En Route airspace with high density Terminal area**

	Airport	Terminal	En Route	Total
AUTOMET	N/A	4.4	6.2	
Worst Case	N/A	4.4 (1)	6.2 (1)	10.6

Note: (x) is domain multiplier (K-bits per second)

2015 AUTOMET Viable Alternatives

- AUTOMET type data currently delivered via ACARS network
- Assume transition to VDL-2 network
- VDL-2 national network operated by CSP since 2001
- VDL-2 single frequency effective data rate is 19.2 kbps.
  - 4 frequencies used for AOCDL - 76.8 kbps
  - This is sufficient to support the projected demand
- UAT, SATCOM could support the load requirement
  - Unlikely use if existing network can support requirement

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft report airborne weather to improve weather nowcasting/forecasting	AUTOMET		3					3		3
3 Acceptable Alternative		☐ NAS Architecture								

2015 APAXS Load Analysis Results

APAXS Messages

Msg ID (M#)	Message Type
M5	Airline Business Support: Electronic Database Updating
M7	Airline Business Support: Passenger Re-Accomodation
M31	Passenger Services: On Board Phone
M42	Miscellaneous "at-seat" services (TV,Internet,Radio)

- **Assume APAXS in En Route Domain only**

	En Route Uplink	En Route Downlink
APAXS - Domain	132	116
APAXS - CONUS	2,635	2,320

(K-bits per second)

2015 APAXS Viable Alternatives

- It is likely that commercial demand will drive broadband satellite service to the cabin by the 2007 time frame.
- The presence of APAXS may provide an opportunity to support air traffic services that would not be possible otherwise.
  - Note, there are no plans for this in the current NAS architecture.

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Passengers enjoy in-flight television, radio, telephone, and internet service	APAXS								✓	✓
✓ Acceptable Alternative		☐ NAS Architecture				★ Restricted Operation				

Combined Peak Data Message Traffic for All Aircraft Classes in 2007, 2015

Data Message Traffic for All Classes of Aircraft (K-bits per second)						
2015	**Airport Uplink**	**Airport Downlink**	**Terminal Uplink**	**Terminal Downlink**	**En Route Uplink**	**En Route Downlink**
FIS	0.2	0.0	0.9	0.0	6.9	0.0
TIS	23.7	0.0	7.0	0.0	20.5	0.0
CPDLC	3.4	2.9	1.3	0.9	1.1	1.3
DSSDL	0.2	0.3	0.1	0.2	0.1	0.1
AOC	0.4	8.4	0.6	8.5	0.2	3.5
ADS Reporting	0.0	16.1	0.0	3.3	0.0	1.5
AUTOMET	0.0	0.0	0.0	4.4	0.0	6.2
APAXS	0.0	0.0	0.0	0.0	131.7	115.5

Data Message Traffic for All Classes of Aircraft (K-bits per second)						
2007	**Airport Uplink**	**Airport Downlink**	**Terminal Uplink**	**Terminal Downlink**	**En Route Uplink**	**En Route Downlink**
FIS	0.2	0.0	0.9	0.0	6.9	0.0
TIS	21.3	0.0	6.4	0.0	18.5	0.0
CPDLC	0.9	0.8	0.3	0.2	0.3	0.3
DSSDL	0.0	0.1	0.0	0.0	0.0	0.0
AOC	0.4	7.0	0.5	7.1	0.2	2.9
ADS Reporting	0.0	4.3	0.0	0.9	0.0	0.4
AUTOMET	0.0	0.0	0.0	1.2	0.0	1.7
APAXS	0.0	0.0	0.0	0.0	33.5	29.4

2015 Architecture Alternatives Summary

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft continuously receive Flight Information to enable common situational awareness	**FIS**					✓		✓	✓	
Aircraft continuously receive Trafic Information to enable common situational awareness	**TIS**					✓		✓	✓	
Controller - Pilot Communication	**CPC**	✓		✓						
Controller - Pilot messaging supports efficient Clearances, Flight Plan Modifications, and Advisories (including Hazardous Weather Alerts)	**CPDLC**			✓						
Aircraft exchange performance / preference data with ATC to optimize decision support	**DSSDL**			✓						
Aircraft continously broadcast their position and intent to enable optimum maneuvering	**ADS-B**				✓		✓	✓		
Pilot - AOC data exchange supports efficient air carrier/air transport operations and maintenance	**AOCDL**		✓					✓		✓
Aircraft report airborne weather to improve weather nowcasting/forecasting	**AUTOMET**		✓					✓		✓
Passengers enjoy in-flight television, radio, telephone, and internet service	**APAXS**								✓	✓

✓ Acceptable Alternative

NAS Architecture

AATT CSA Recommendation

Top Down vs Bottom Up Architecture

- ✈ **Top Down Architecture optimizes at the “system” level**
  - May contain sub-optimal solutions for 1 or more sub-systems
  - For this task: Minimize the number of radio’s on the aircraft and the ground infrastructure
- ✈ **Bottom Up Architecture optimizes at the “sub-system” level**
  - Optimizes each sub-system without regard to total system
  - For this task: Select optimum radio

Top Down Observations

- Human / DSS ATC interfaces satisfied by VDL-3 Link - NAS Architecture Baseline
  - CPC
  - CPDLC
  - DSSDL

	Airport	Terminal	En Route
CPC	1 voice channel per sector		
CPDLC	6.3	2.2	2.4
DSSDL	0.5	0.3	0.2
Total	6.8	2.5	2.6

- Human / AUTOMET AOC interfaces satisfied by VDL-2 Link - Consistent with current planning, Not in NAS Arch
  - AOCDL
  - AUTOMET

	Airport	Terminal	En Route
AOCDL	8.8	9.1	3.7
AUTOMET	N/A	4.4	6.2
Total	8.8	13.5	9.9

- Dynamic Information Base satisfied with Broadband Link - No integrated plan for NAS Broadband data
  - FIS
  - TIS
  - ADS-B

	Region
FIS	12.4
TIS	55.5
ADS-B	20.9

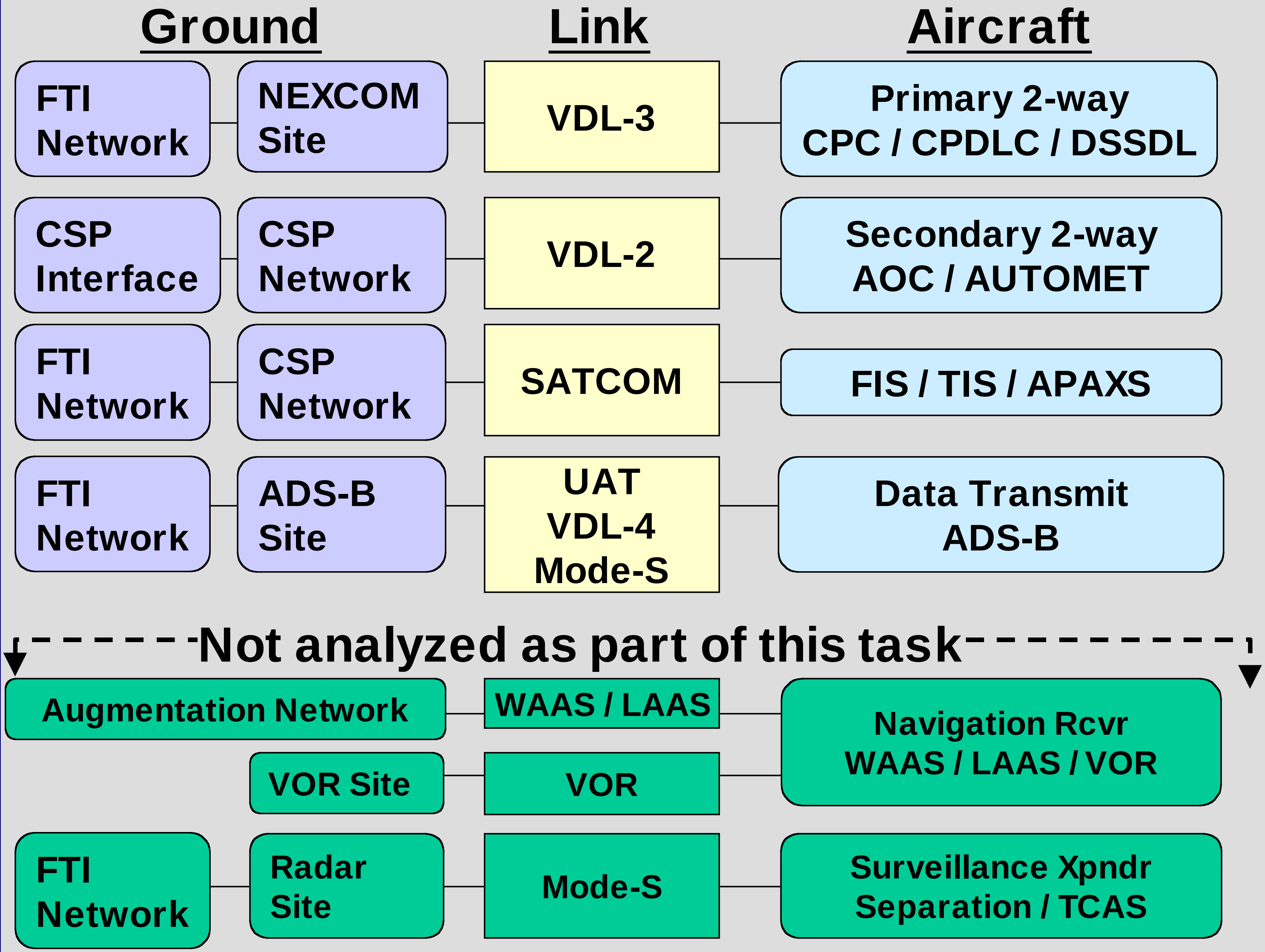
- Broadband data solution can be Terrestrial or Space Based

Broadband Data Considerations

- ADS-B link decision - can have major impact on Terrestrial vs Space based decision
- SATCOM implementation - driven by commercial cabin services (could lead to class 1 Avionics cost/performance issues)

	UAT	SATCOM
Base	• Terrestrial • FAA Radar, Navigation and/or Air-Ground Communication sites	• Space • Assume desirable CONUS coverage • Commercial service providers
Capacity	1Mbps	≥ 2Mbps
PRO's	– If selected as ADS-B link, all aircraft would eventually have UAT radio – Use of FAA sites – Avionics design complete – standards in development	• CONUS coverage without maintenance of terrestrial network • Higher data rates • Most likely will be available from commercial service providers
CON's	– Maintenance of terrestrial network – Additional radio required if not selected as part of ADS-B	• Immature avionics design - no standards – unproven for small GA aircraft • Additional radio required for non-APAXS equipped users

2015 Top Down Architecture - SATCOM Data



2015 Top Down Architecture - UAT Data

Ground		Link	Aircraft
FTI Network	NEXCOM Site	VDL-3	Primary 2-way CPC / CPDLC / DSSDL
CSP Interface	CSP Network	VDL-2	Secondary 2-way AOC / AUTOMET
FTI Network	CSP Network	UAT	Data Receive FIS / TIS
FTI Network	ADS-B Site	UAT	Data Transmit ADS-B
CSP Network		SATCOM	APAXS

Not analyzed as part of this task

Ground		Link	Aircraft
Augmentation Network		WAAS / LAAS	Navigation Rcvr WAAS / LAAS / VOR
	VOR Site	VOR	Navigation Rcvr WAAS / LAAS / VOR
FTI Network	Radar Site	Mode-S	Surveillance Xpndr Separation / TCAS

Interim Architecture Development

- 2007 AATT Architecture driven by 2015 AATT Architecture
  - Multiple Communication Solutions exist - pick solutions on the path to 2015 AATT
- 2007 AWIN Architecture part of the 2007 AATT Architecture
  - FIS
  - AUTOMET
  - CPC

2007 AATT CSA

- **Human voice communications satisfied by VHF-AM**
  - **CPC: Transition to VDL-3**
- **ATC data message interfaces satisfied by VDL-2 Link - NAS Architecture Baseline**
  - **CPDLC: Transition to VDL-3**
  - **DSSDL: Transition to VDL-3**
- **Human / AUTOMET AOC interfaces satisfied by VDL-2 Link - No change from 2015, Not part of NAS Architecture**
  - **AOCDL**
  - **AUTOMET**
- **Dynamic Information Base satisfied with Multiple Links - No integrated plan for NAS Broadband data**
  - **FIS: CSP supports VDL-B and Broadband solution**
  - **TIS: Broadband solution**
  - **ADS-B: Follow ADS-B link decision**

2007 Architecture Alternatives Summary

Operational Concept	Technical Concept	VHF-AM	VDL-2/ ATN	VDL-3/ ATN	VDL-4/ ATN	VDL-B	Mode-S	UAT	SATCOM-Broadcast	SATCOM-2way
Aircraft continuously receive Flight Information to enable common situational awareness	FIS					✓		✓	✓	
Aircraft continuously receive Traffic Information to enable common situational awareness	TIS					✓		✓	✓	
Controller - Pilot voice communication	CPC	✓								
Controller - Pilot messaging supports efficient Clearances, Flight Plan Modifications, and Advisories (including Hazardous Weather Alerts)	CPDLC		✓							
Aircraft exchange performance / preference data with ATC to optimize decision support	DSSDL		✓							
Aircraft continously broadcast their position and intent to enable optimum maneuvering	ADS-B				✓		✓	✓		
Pilot - AOC data exchange supports efficient air carrier/air transport operations and maintenance	AOCDL		✓					✓		✓
Aircraft report airborne weather to improve weather nowcasting/forecasting	AUTOMET		✓					✓		✓
Passengers enjoy in-flight television, radio, telephone, and internet service	APAXS								✓	✓

✓ Acceptable Alternative NAS Architecture AATT CSA Recommendation

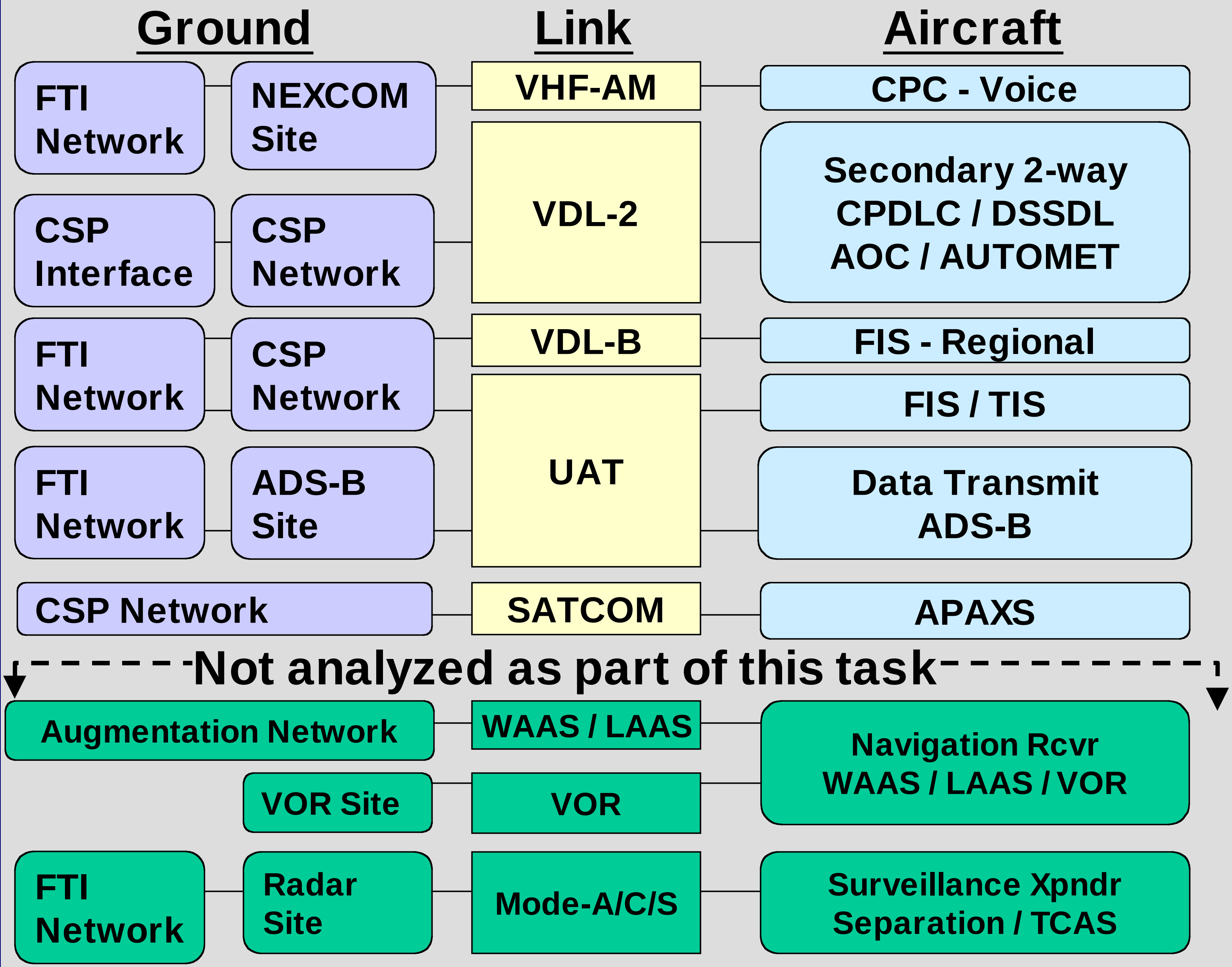
2007 Architecture - SATCOM Data

Ground		Link	Aircraft
FTI Network	NEXCOM Site	VHF-AM	CPC - Voice
CSP Interface	CSP Network	VDL-2	Secondary 2-way CPDLC / DSSDL AOC / AUTOMET
FTI Network	CSP Network	VDL-B	FIS - Regional
		SATCOM	FIS / TIS / APAXS
FTI Network	ADS-B Site	UAT VDL-4 Mode-S	Data Transmit ADS-B

Not analyzed as part of this task

Augmentation Network		WAAS / LAAS	Navigation Rcvr WAAS / LAAS / VOR
	VOR Site	VOR	
FTI Network	Radar Site	Mode-A/C/S	Surveillance Xpndr Separation / TCAS

2007 Architecture - UAT Data



Hybrid Architecture Considerations

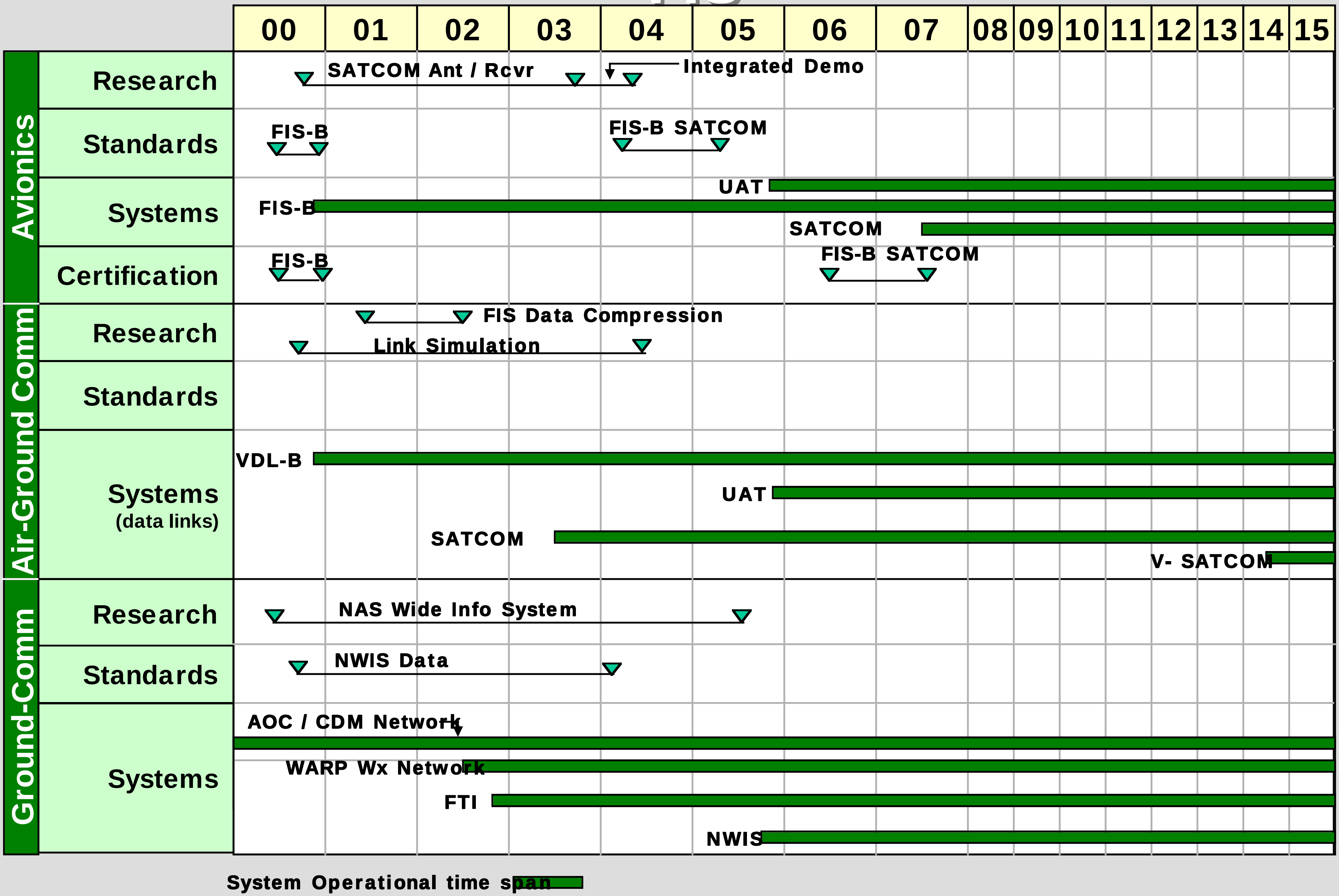
- ✈Hybrid Architecture
  - – Multiple links support single technical concept
    - Combination of 2-way and Broadcast
    - Combination of Terrestrial and Space
  - – Driven by Operational, Cost, Schedule, Performance constraints / trades
    - Cost considerations not part of TO24 Analysis
    - No other drivers identified at TO24 Level of Analysis

TASK 8

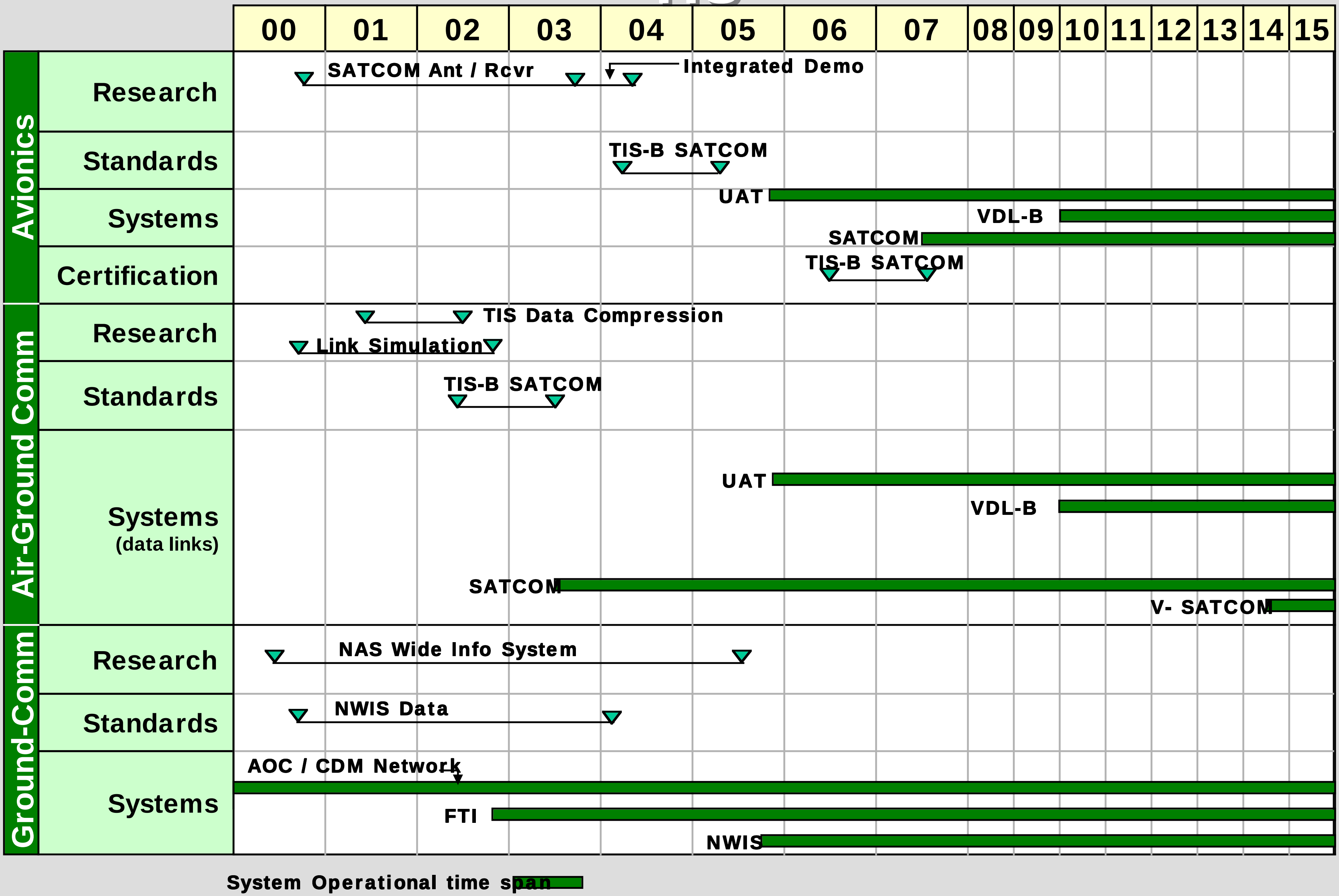
Transition

Defines the key milestones and activities for implementation of each of the technical concepts and communications links.

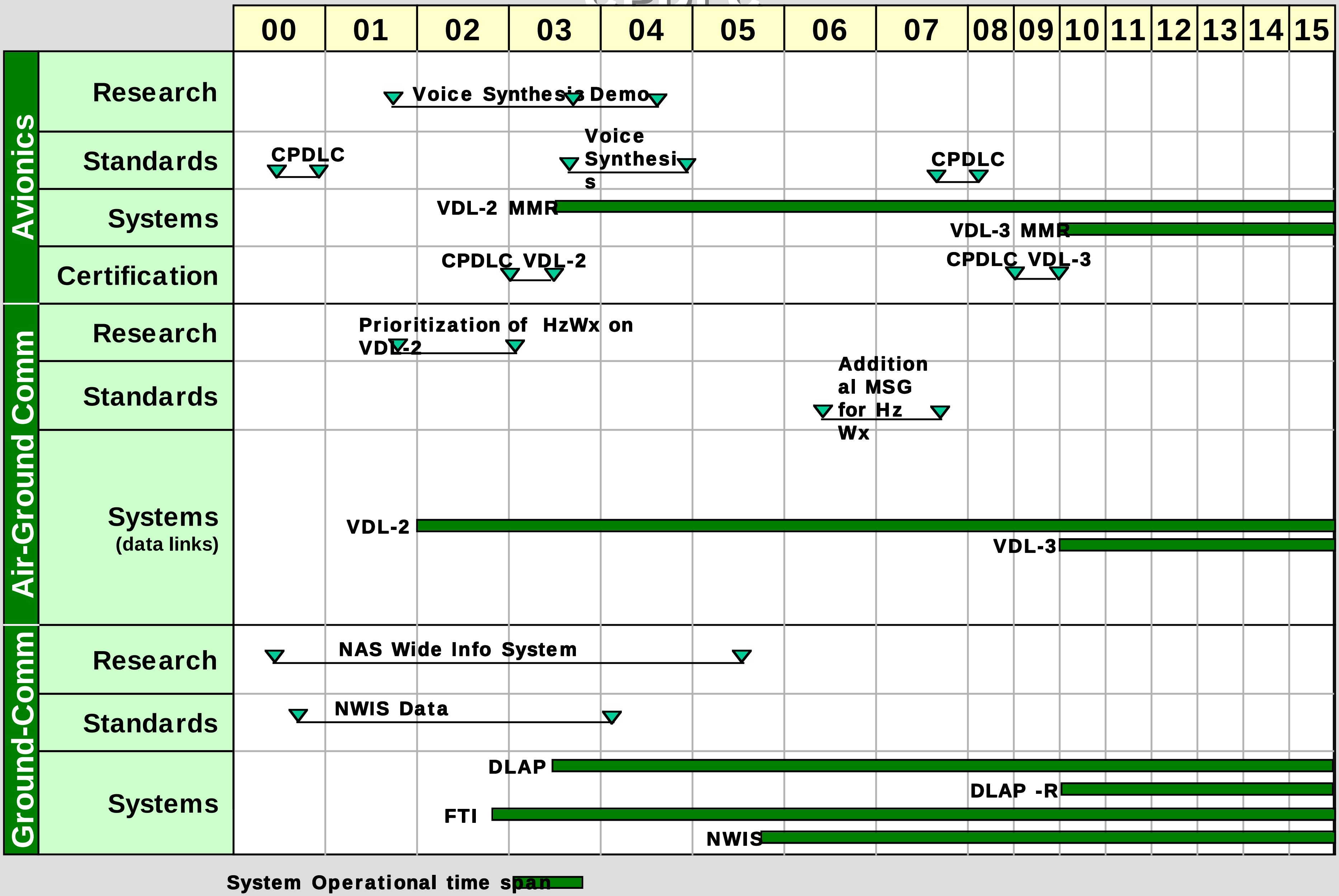
AATT Communication Architecture Schedule - FIS



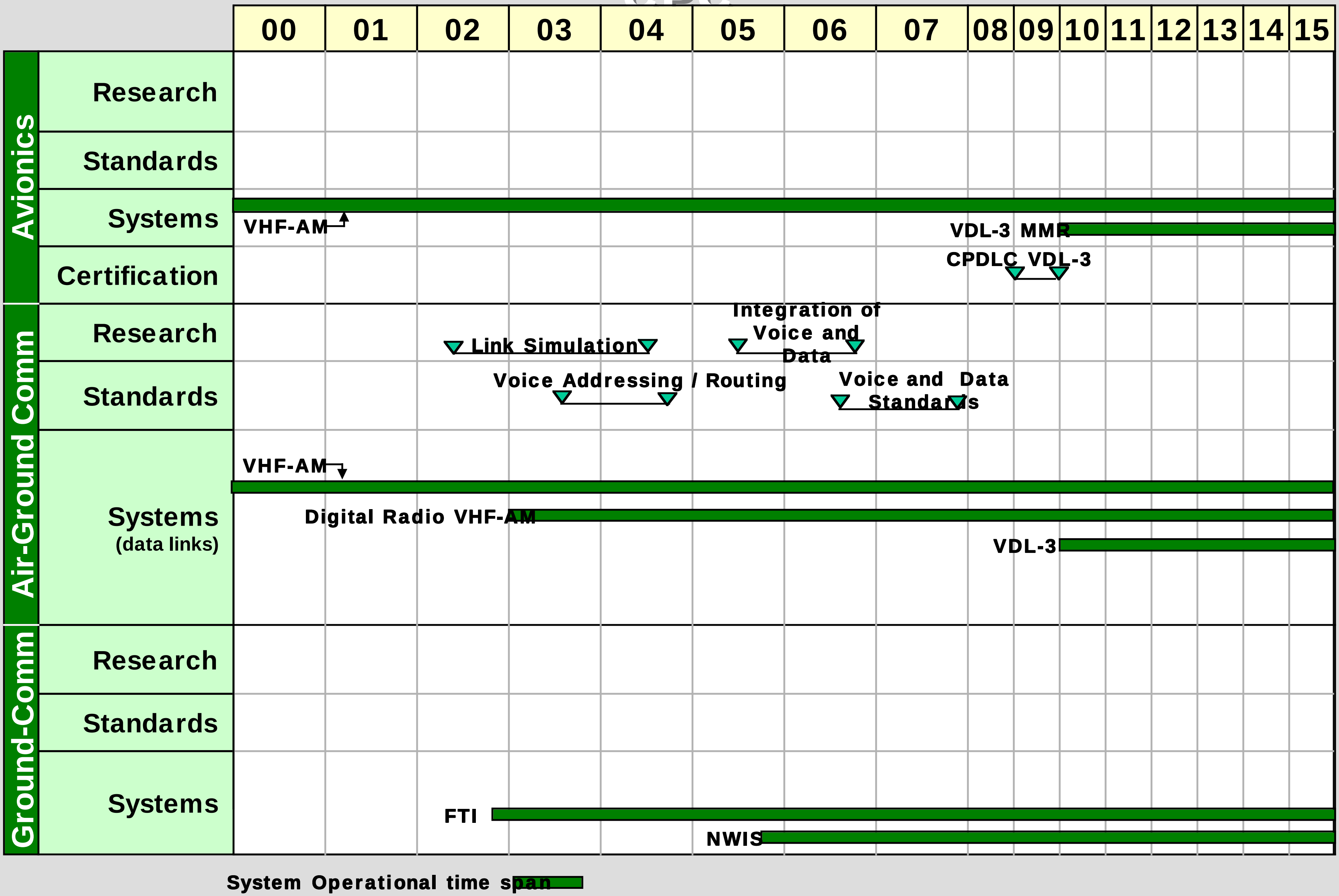
AATT Communication Architecture Schedule - TIS



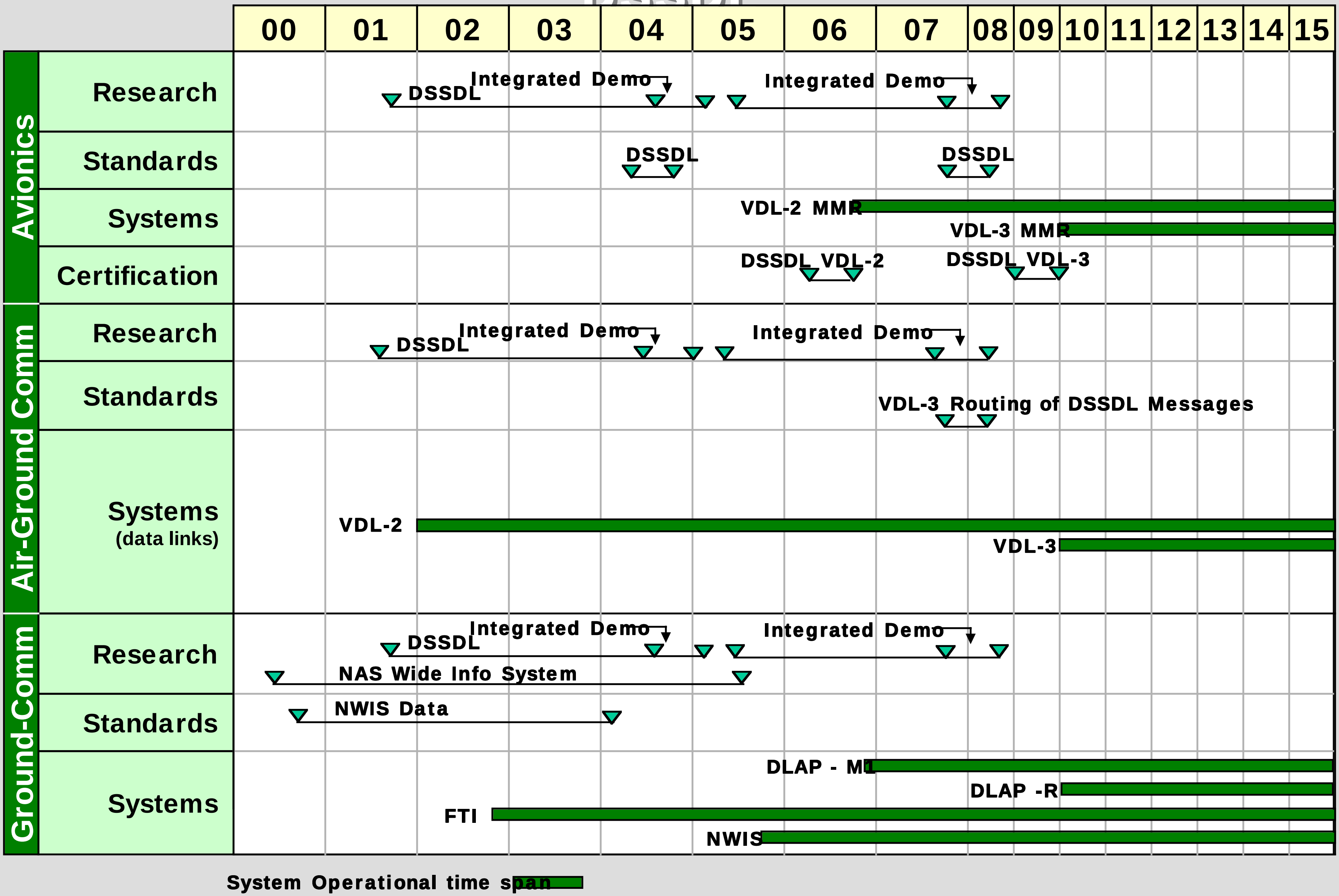
AATT Communication Architecture Schedule - CPDLC



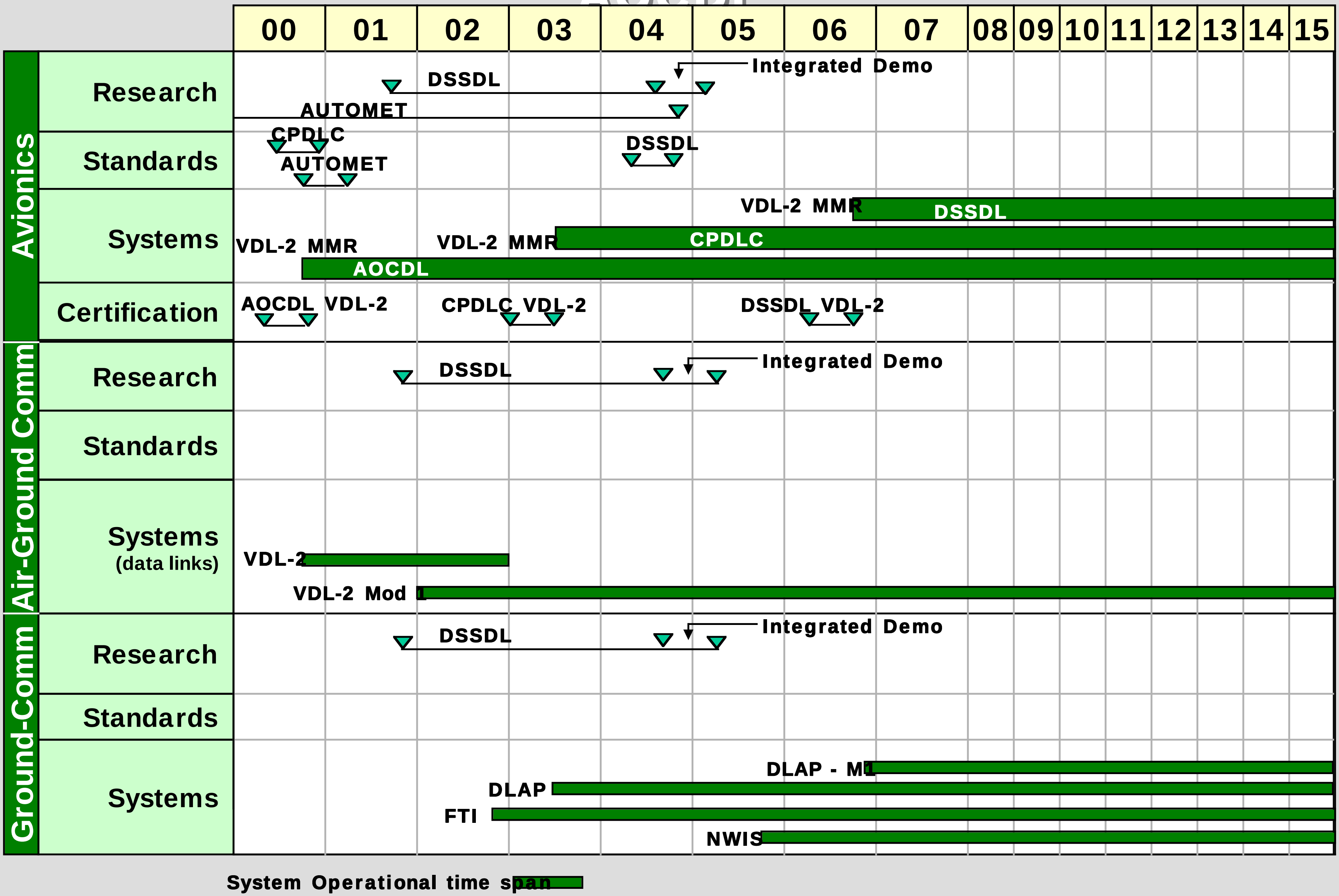
AATT Communication Architecture Schedule - CPC



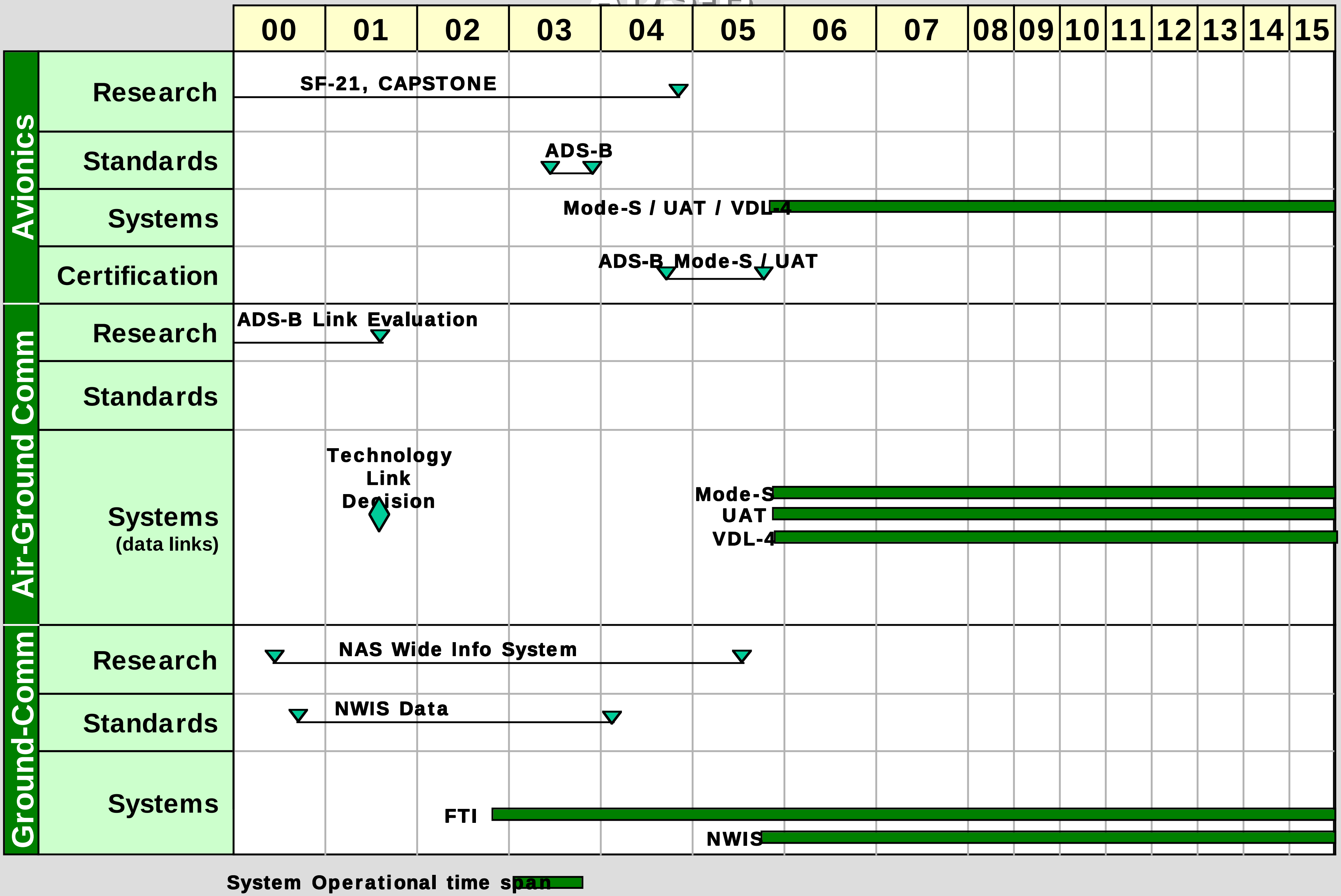
AATT Communication Architecture Schedule - DSSDL



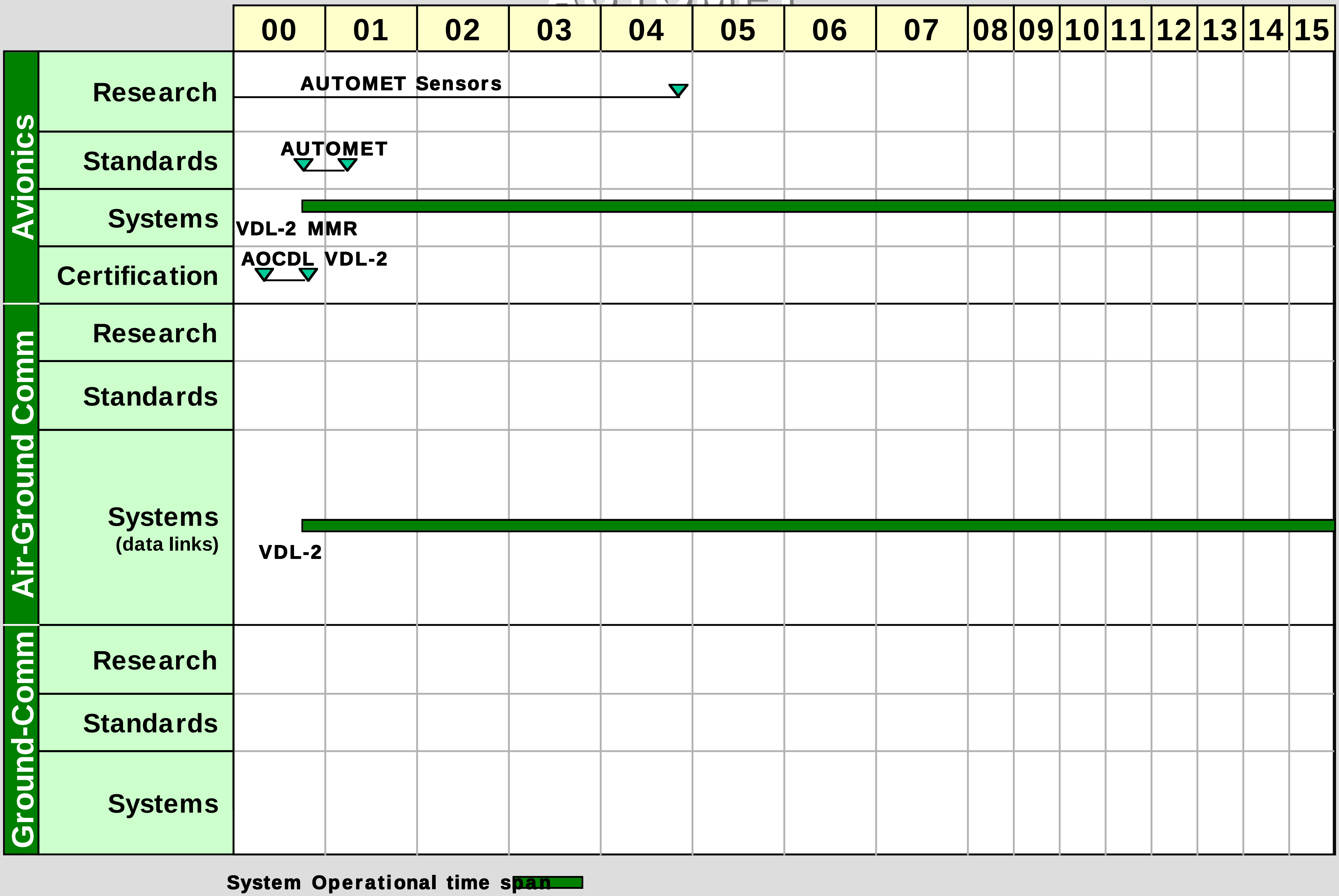
AATT Communication Architecture Schedule - AOCDL



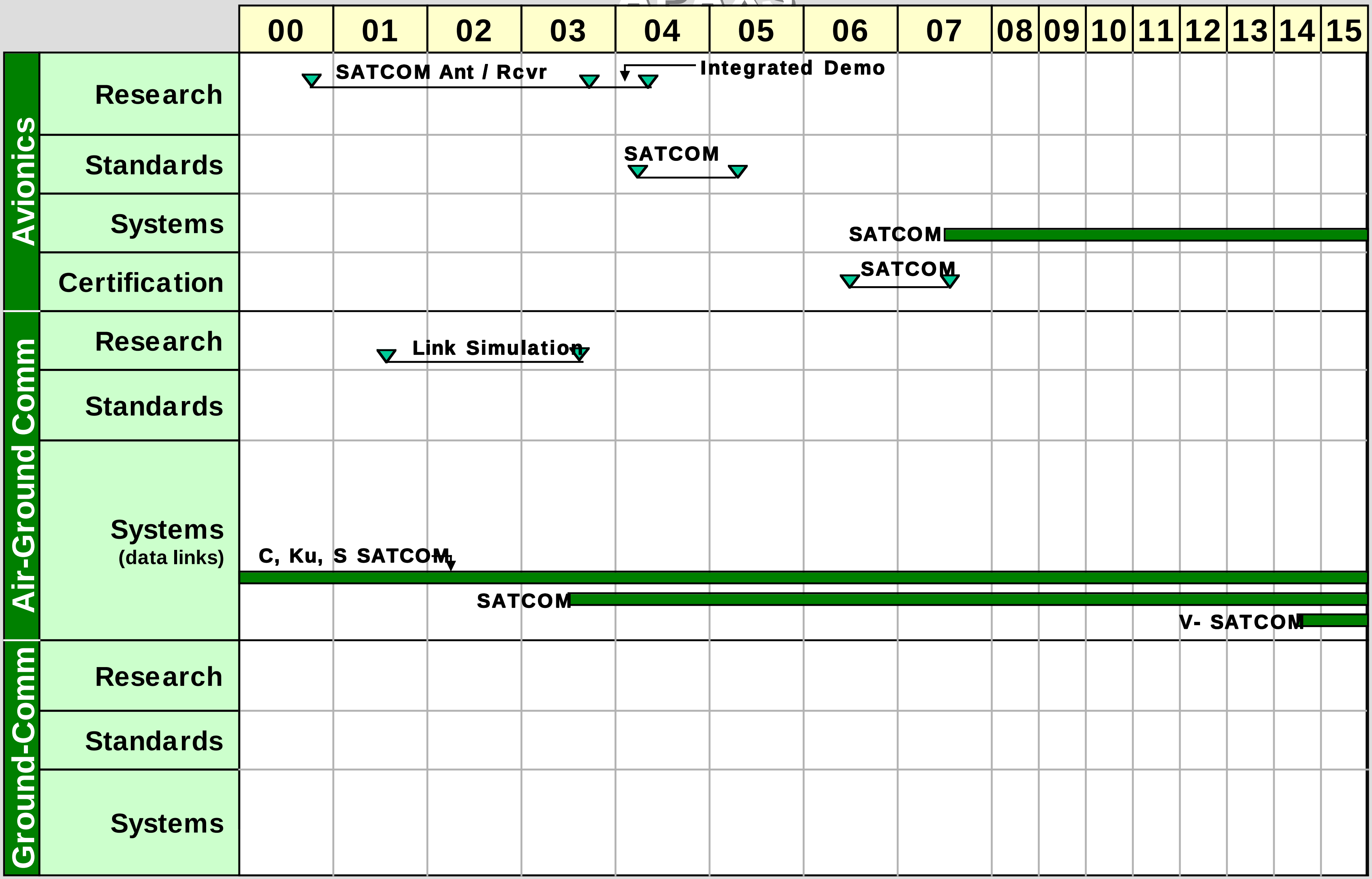
AATT Communication Architecture Schedule - ADS-B



AATT Communication Architecture Schedule - AUTOMET

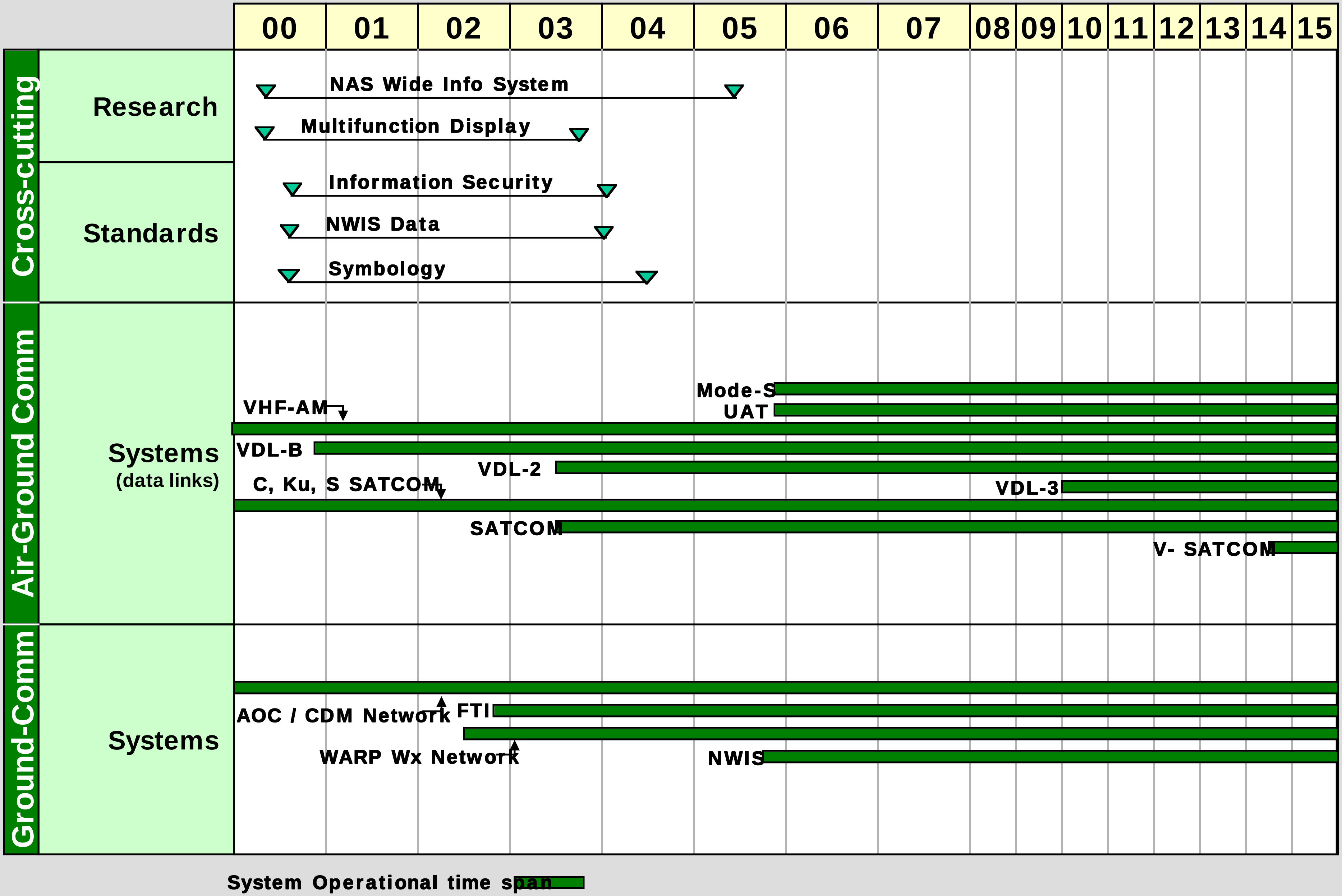


AATT Communication Architecture Schedule - APAXS



System Operational time span

AATT Communication Architecture Schedule - Cross-cutting



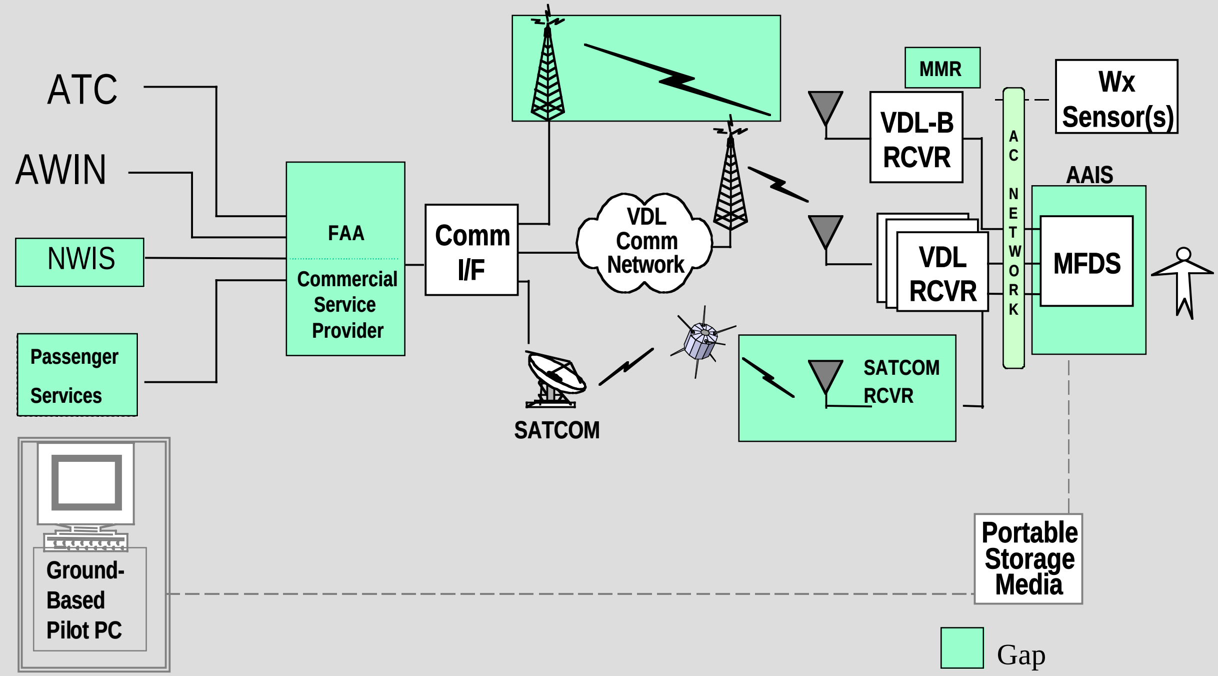
Communications Technology Gaps, Solution Alternatives and Areas for R&D
Tasks 10 & 11

May, 2000

AATT TO24
SAIC Team

Communications Technology Gaps & Solution Alternatives

Task 10 | **Ground Systems** | **Air / Ground Comm** | **Aircraft**



Task 11

Communications Gaps & Solution Alternatives by Year/Segment

Architecture Requirement	Communications Technology Gap Areas	System or Component	Segment		
2007/2015			Ground	Air	Space
2007	Advanced Aircraft Information System	New System Required			
	High Speed Network (Flight Deck/Cabin)	Improved Component		x	
	Server	Improved Component		x	
	Multifunctional Displays	Improved Component		x	
	Intelligent Router	Improved Component		x	

High Speed Aircraft LAN

- Distribution of data within the aircraft will require a high speed bus or local area network (LAN)
- Cockpit distribution of information
- Cabin services such as In-Flight Entertainment (IFE) and Internet applications
- Aircraft networks will have additional requirements beyond these of terrestrial LANs:
  - FAA certification including consideration of EMI, fire safety, redundancy, failure modes, security and maintenance.
  - Information security, quality of service provisions and a priority scheme.

Multifunction Display

Types of information for the pilot display are:

- **Heads-up display symbology**
- **Fused display information about terrain, tower obstacles, and proximate aircraft**
- **Hazardous weather contours such as wind shear in terminal area, and icing, hail, turbulence and lightning areas**
- **Taxi instructions including active runways and airport layout**

Communications Gaps & Solution Alternatives by Year/Segment (continued)

Architecture Requirement	Communications Technology Gap Areas	System or Component	Segment		
2007/2015			**Ground**	**Air**	**Space**
2015	Traffic Information System	New System Required			
	Com. Interface to TIS				
	(standard data set, access protocol, user verification)	New System	x	x	

Communications Gaps & Solution Alternatives by Year/Segment (continued)

Architecture Requirement	Communications Technology Gap Areas	System or Component	Segment		
2007/2015			Ground	Air	Space
2007	SATCOM	New System, Component and Datalink Required			
	Multi-mode Radio with Ka Band Interface	Improved Component		x	
	Development of efficient modulation techniques for Ka satellite bands	Improved Component		x	x
	Mobile Standards	Improved System			x
	Ka Band Receiver Improvements	Improved Component		x	
	Ka Band Antenna Improvements	Improved Component		x	

Communications Gaps & Solution Alternatives by Year/Segment (continued)

Architecture Requirement	Communications Technology Gap Areas	System or Component	Segment		
2007/2015			Ground	Air	Space
2007	VHF Improvements				
	Directional VHF Antennas	Improved Component		x	
	Voice/Data Vocoders	Improved System	x	x	
	Modulation	Improved System	x		
	Virtual Network	Improved System	x		
	Compression	Improved Technology	x		
	Voice synthesis	Data Link	x		

Cross Cutting Technology Gaps

Architecture Requirement 2007/2015	***Cross Cutting Technology Issues***	**System or Component**	**Segment**		
			Ground	**Air**	**Space**
2015	**NAS-Wide Information System**	**New System Required**			
	Com. Interface to Distributed NAS Wide Database (standard data set, access protocol, user verification)	New System	x	x	
2007	**Information Security**	**Improved Datalink Required**			
	Authentication	New System	x	x	
	Data Validation	Improved System	x	x	
	Protection from Interference	Improved System	x	x	x

AATT TO 24 Challenges

Evolving Standards, concepts, product definitions, communications technologies and services (AUTOMET, EPiRep, VDL-B, UAT, VDL -4)

Variations and inconsistencies in documented message traffic and aircraft projections

Pending link decisions that could impact recommendations (ADS-B)

Concept definitions (NWIS, DAG)

Market drivers (APAXS)

AATT TO24 Accomplishments

- Provided a framework for future decision making
- Provided a coherent structure for future research and analysis
- Collected, sorted and categorized input from multiple reports
- Provided traceability from user requirements to services and communications links through the use of functional capabilities and technical concepts
- Developed a repository for continued data collection
- Determined viable links for each service from a top down and bottom up perspective
- Identified key milestones for transition to 2015 AATT CSA
- Identified gap areas and solution candidates for further research

AATT TO 24 Status

Individual Task Reports Delivered:

- July 99-May 00

AATT TO24 Team Presentations:

- May, July, September, October, 1999
- January, February, March, 2000

Final Presentation:

- May 10-11, 2000

Final Report:

- May 26, 2000

A/A	Air to Air
A/G	Air to Ground
AAC	Airlines administrative communications
AAIS	Advanced Aircraft Information System
AATT	Advanced Air Transportation Technologies
ACARS	aircraft communications addressing and reporting system
ADAS	AWOS data acquisition system
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance - Broadcast
AFSS	automated flight service station
AIM	Aeronautical Information Manual
AIRMET	Airman's Information Manual
AM	amplitude modulation
AMS	acquisition management system
AMS(R)S	Aeronautical Mobile Satellite (Route) Service
AMSRS	Aeronautical Mobile Satellite (Route) Service
AMSS	Aeronautical Mobile Satellite System
AOC	airline operations center
ARINC	Aeronautical Radio Inc.
ARTCC	Air route traffic control center
ASIST	Aeronautics Safety Investment Strategy Team
ASOS	automated surface observing system
ASR-9	airport surveillance radar- nine
ASR-WSP	airport surveillance radar- weather system processor
ATC	Air Traffic Control
ATC DSS	Air Traffic Control Decision Support Systems
ATCSCC	Air traffic Control System Command Center
ATCT	Air Traffic Control Tower
ATIS	Automatic Terminal Information Service
ATM	air traffic management
ATN	Aeronautical Telecommunication Network
ATS	air traffic services
ATSP	air traffic service provider
AvSP	Aviation Safety Program
AWIN	Aviation Weather Information Services
AWIN	Aviation Weather Information
AWOS	automated weather observing system
BER	bit error rate
BER	Bit Error Rate
CD	compact disk
CDM	Collaborative Decision Making
CDMA	Code Division Multple Access
CDTI	Cockpit Display of Traffic Information
CNS	Communications, Navigation and Surveillance
CONOPS	concept of operations
CONUS	Continental United States
COTS	Commericial Off-The-Shelf
CP	conflict probe
CPDLC	Controller-Pilot Data Link Communications System
CPU	central processing unit
CSA	communications system architecture
CSMA	Carrier Sense Multiple Access
CTAS	Center-TRACON Automation system
CWA	Center Weather Advisory
D8PSK	Differential Eight-Level Phase Shift Keying
DA	descent advisor
DAG-TM	Distributed Air/Ground Traffic Management
DoD	Department of Defense
DOT	Department of Transportation
DOTS	dynamic ocean tracking system
DSR	Display System Replacement
EMC	Electromagnetic Capability
EMI	Electromagnetic Interference
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FANS 1/A	future air navigation system
FAR	Federal Air Regulations
FAR	Federal Aviation Regulation
FBO	Fixed Base Operator
FBWTG	FAA bulk weather telecommunications gateway
FCC	Federal Communications Commission
FDM	flight data management
FDP	flight data processor
FEC	Frame error check
FEDSIM	Federal Systems Integration and Management Center
FFP1	Free Flight Phase 1
FIS	Flight Information Service
FL	flight level
FMS	Flight Management System
FOQA	Flight Operational Quality Assurance
FP	flight plan
FSS	flight service station
FSS	Fixed Satellite Service
G/G	Ground-to-Ground
G/T	Gain to System Noise Temperature Ratio
GA	General Aviation

GEO	Geostationary Earth Orbit
GPS	Global Positioning System
HARS	high altitude route system
HF	high frequency
HF	High Frequency
ICAO	International Civil Aviation Organization
IF	interface
IFE	In-Flight Entertainment
IFR	Instrument flight rules
IFR	Instrument Flight Rules
IMC	instrument meteorological conditions
IOC	initial operating capability
IP	Internet Protocol
ITWS	Integrated terminal weather system
IWF	Integrated Weather Forecast
KBPS	Kilobites Per Second
LAN	Local Area Network
LEO	Low Earth Orbit
LLWAS	Low-level wind shear alert system
MBO	Military Base Operations
MDCRS	Meteorological Data Collection and Reporting System
MEO	Medium Earth Orbit
METAR	meteorological aviation report
MFD	Multifunctional Display
MOC	Mission Operational Control
MOPS	minimum operational performance standards
MSS	Mobile Satellite Service
MTBF	Mean Time Between Failure
N/A	Not Applicable
NAS	National Airspace System
NAS RD	NAS Requirements Document
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Controllers Association
NAWIS	National Aeronautics and Space Administration
NESDIS	national environmental satellite, data, and information service
NEXCOM	Next Generation A/G Communications System
NEXRAD	next generation radar
NLDN	national lightning detection network
NOTAM	Notice to Airman
NWS	National Weather Service
NWS/OSO	National Weather Service/Office of Systems Operations
OASIS	operational and supportability implementation system
OAT	Office of Advanced Technology
ODAPS	oceanic display and planning system
PFAST	passive final approach spacing tool
PIREP	Pilots Report
PIREPS	pilot reports
PSK	Phase Shift Keying
QAM	Quadrature Modulation
QoS	Quality of Service
RA	resolution advisory
RCP	Required Communications Performance
RD	requirements document
RF	Radio Frequency
RTCA	RTCA, Incorporated
RTO	Research Task Order
RVR	runway visual range
SAIC	Science Applications International Corporation
SAR	Search and Rescue
SARP	Standards and Recommended Practices
SATCOM	Satellite Communications
SIGMET	Significant Meteorological Information
SOW	Statement of Work
SPECI	Special Weather Report
SSR	Secondary Surveillance Radar
STC	supplemental type certificate
SUA	Special Use Air Space
TAF	Terminal Aerodrome Forecast
TBD	to be determined
TDWR	terminal Doppler weather radar
TFM	traffic flow management
TIS	Traffic Information Services
TM	traffic management
TMS	traffic management system
TRACON	Terminal Radar Approach Control Facility
TRM	Technical Reference Model
TWDL	Two-Way Data Link
TWEB	Transcribed Weather Broadcast
TWIP	terminal weather information for pilots
VDL	very high frequency digital link
VFR	visual flight rules
VHF	very high frequency
VOR	VHF-Omni Directional Range
WAAS	Wide Area Augmentation System
WAN	Wide Area Network
WARP	weather and radar processor
WJHTC	William J. Hughes Technical Center
WMSCR	weather message switching center replacement
Wx	Weather
WxAP	weather accident prevention